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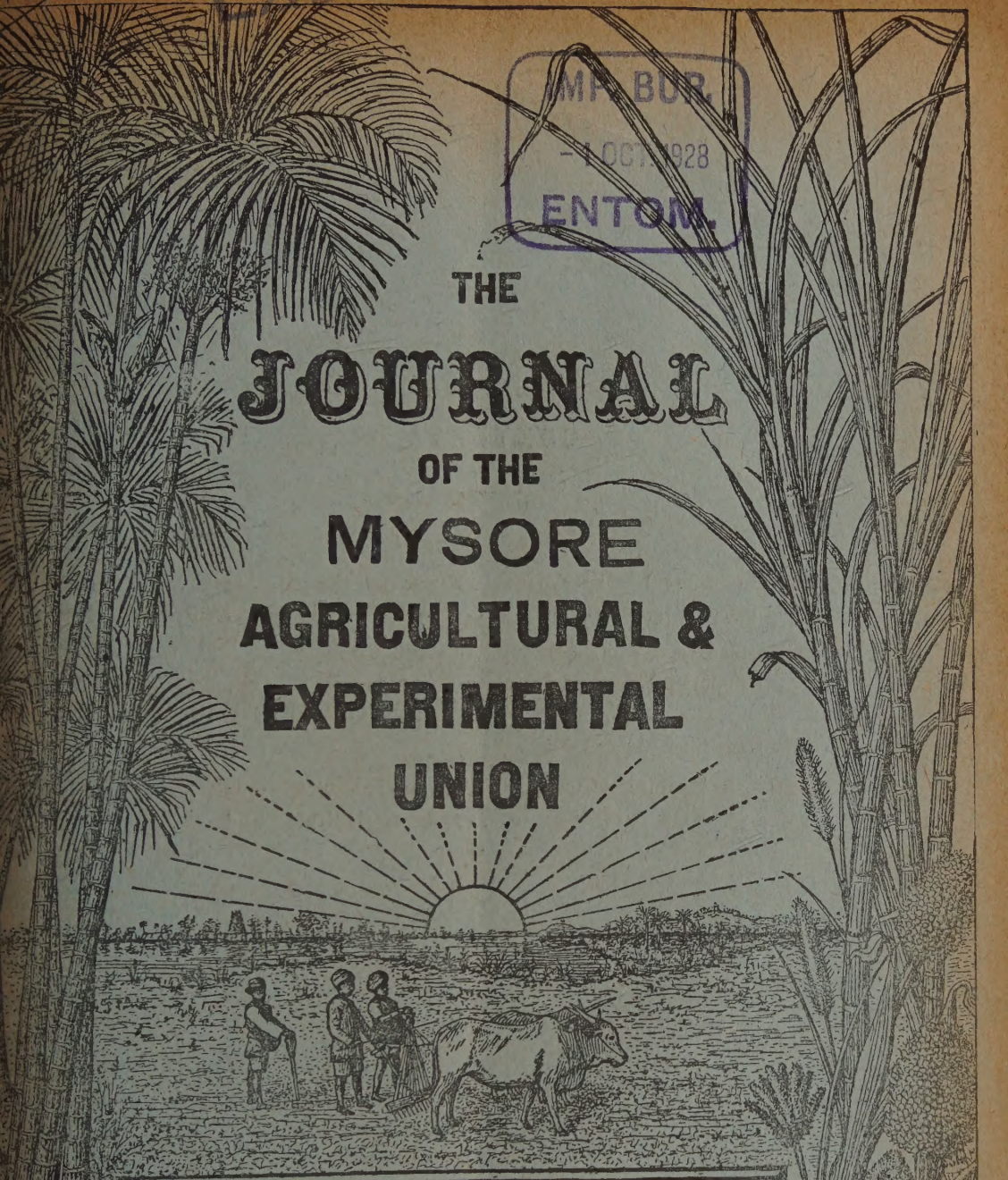

Vol. VIII] 1926 [No. 2

PRINCIPAL CONTENTS.

The Government Experimental Farms in the Mysore State.

Sericulture in Mysore—By N. Rama Rao, B.A., B.L., Superintendent of Sericulture in Mysore.

Agriculture and Science—By Albert Howard, C.I.E., M.A.

CONTENTS.

Pages

The Government Experimental Farms in the Mysore State .. .. 65—74

Sericulture in Mysore—By N. Rama Rao, [B.A., [B.L., Superintendent of Sericulture in Mysore .. 75—92

SELECTIONS—

Danish Farming—Curing of Coffee—The Technique of Rice Growing in Japan—Agriculture and Science .. .. 92—123

The Journal
of the
Mysore Agricultural
and
Experimental Union.

Vol. VIII. 1926 No. 2

The Government Experimental Farms in the Mysore State.*

The Government Experimental Farms are five in number, *viz.*, (*a*) The Hebbal Farm, (*b*) The Marthur Farm, (*c*) The Babbur Farm, (*d*) The Nagenahalli Sugarcane Farm, and (*e*) The Balehonnur Coffee Farm.

The Hebbal Farm.

This is the oldest of the five Farms and was opened in the year 1904. It is situated in the village of that name, about five miles from Bangalore. The tract is representative in a general way of the red soil areas which largely comprise the Bangalore, Tumkur and Kolar Districts.

It comprises an area of 20 acres of wet land and 60 acres of dry land. The wet land is commanded by a good irrigation tank and is further protected by an irrigation well.

On the farm is also situated the Agricultural School, with its adjuncts, the Veterinary Hospital and the Hebbal Dairy.

A small workshop which comprises the Agricultural Engineering Section and which also gives instruction in carpentry, smithy work and fitter's work to the students is also located on the farm.

* Reprinted from "Agriculture in Mysore".

A herd of cross-bred (Merino x local) sheep is also kept on the farm.

The bulk of the farm buildings, and the general lay-out of the farm were designed by Dr. A. Lehmann when he was Agricultural Chemist. A considerable part of the total area of the farm is devoted to the work of plant breeding under the control of the Botanist.

The experimental work on the farm has related mainly to sugar-cane and paddy among wet crops and to ragi among dry crops.

The experimental work of the farm was preceded by a thorough scheme of standardizing of the experimental plots for a few years before they were utilized for the experiments, a feature seldom seen on any other farm in India.

The experiments on *sugar-cane* related to—

(1) time of planting,
(2) maturity of cane,
(3) varietal tests,
(4) manurial tests, and
(5) spacing tests.

Moreover all the breeding work on cane of the Department has been conducted on this Farm.

Work on *paddy* has likewise related to—

(1) manurial tests,
(2) varietal tests,
(3) green manuring,
(4) seed rate,
(5) age of seedlings,
(6) duty of water, and
(7) effect on ploughing after harvest.

Work on *ragi* has related to—

(1) methods of sowing,
(2) green manuring experiments,
(3) mixed and pure cropping.
(4) tillage experiments,
(5) varietal, and
(6) manurial experiments.

It was from the Hebbal Farm that the *short season groundnuts* which are now grown on thousands of acres in the State, were first

introduced into the State. In addition to these, several of the main season varieties of groundnuts, for example, Sogatur, Virginia, Mauritius, Carolina, Transvaal, have been tested and much seed of the first two distributed.

A large variety of implements, ploughs of different kinds, and other tillage implements including the "Spalding deep tillage implement", seed drills, a potato digger for harvesting groundnuts, pumps and engines, threshing machines, reaping machine, etc., have been tried on the farm to determine their suitability to Mysore conditions. All the work in connection with the design and tests of the "Mysore" plough was conducted on the Hebbal Farm.

The results of all the experiments on the farm have been summarized in the chapters on Agricultural Chemistry and Botany which have already appeared in a previous issue of this Journal. The bulletins of the department on the cultivation of ragi and on green manuring describe in full and contain the results of the experiments conducted on these subjects on this farm.

The farm incidentally supplies a large quantity of seeds of the selected varieties of the different crops, principally sugarcane, paddy and ragi.

The Marthur Farm.

The Marthur Farm is situated in the interior of the Malnad near Talaguppe in the Shimoga District not far from the famous Gersoppa Falls. It was opened in the year 1914 with the object primarily of experimenting on "Koleroga" of the arecanut, but was later developed to include experiments on the cultivation of the areca, paddy, sugarcane and other crops suited to the *malnad* tract.

It is 56 acres in extent and fairly typical of the *malnad* areca and paddy area.

Work on the *koleroga of the arecanut* has related not only to the devising of the main remedy, *viz.*, the spraying with the Bordeaux mixture and the importation of a suitable spray pump, the Holder Sprayer which this Department was the first to get out but also to the different "Stickers," resin, casein soda, and their preparation, time of application and so on. Extensive manurial experiments, *viz.*, the testing of the suitability of different kinds of green manure to this area of heavy rainfall, the use of artificial manures, the practice of growing and digging in green manure, have been in progress. The

results have shown that yields per acre can be increased by 50 per cent by the application of a mixture of groundnut oil-cake and superphosphate and of sulphate of potash. The growing of green manure between the rows of the areca palms, in preference or as an adjunct to the usual practice of bringing in leaves from the forest, the damage to which as a consequence has often been protested against, has been continued for many years with success on the farm.

Experiments on *sugarcane* have related not only to the best varieties that could be introduced into this tract, but to the manuring and cultivation side of the question also. The thin Java cane has been found the best, both in the tonnage per acre and in the richness of the juice and above all on the suitability to the tract. Many of the seedling varieties raised on the Hebbal Farm which have proved a great success in other parts of the State have been found much inferior to the Java and hardly able to stand the heavy rainfall. Varietal trials are however a permanent feature of the farm work, new varieties being supplied by the Hebbal Farm. Among the latest varieties, one called H.M. 553 has been successful, and so has H.M. 315, a thin cane much like the Java, but tillering better. With this particular variety, *viz.*, the Java cane, spacing experiments have indicated the desirability of closer planting for really heavy yields.

Paddy being the chief or the sole grain crop of the tract, a number of varieties suitable to the tract have been on trial. As a preliminary to more systematic work, the varieties have been purified and tested as to what extent they breed true. Promising individual selections and trials are to follow. A good deal of demonstration work on the economic transplanting of paddy which has been largely and successfully popularized in the *malnad* paddy areas was conducted on the farm in the earlier years.

Pepper being one of the most important of *malnad* crops, experimental work on this crop is carried on on the farm. A large number of varieties gathered from different parts of both Mysore and Malabar have been planted and some of the varieties have begun to yield. It is the object of the farm to propagate the best among the varieties and distribute to the neighbourhood as in the case of the other crops.

For demonstration purposes, the farm has also a silo. As in the wet season throughout the *malnad* there is a luxuriant growth of grass which does not admit of being cut and dried into hay, the practice

of *silage making* has been deemed a desirable one to introduce in the *malnad*. On the farm excellent silage has been made in ordinary pit silos. It is expected that the example of the farm in this respect will be copied by the raiyats of the neighbourhood.

Attention is also paid on the farm to the introduction and testing of varieties of certain minor crops such as *ragi*, *chillies* and *plantains*. Two selections of *chillies* called C.P. I. and C.P. II have also been distributed on a small scale through the *malnad*, as they are found to be good yielders suitable to these districts.

The farm has also *an orchard area*, on which several kinds of fruit trees have been planted to test their suitability to the tract, as in case of positive results a great deal of planting up of the waste land can be profitably recommended.

The Nagenahalli Farm.

The Farm was sanctioned in 1917 but it was not until 1920 that irrigation water was available when the terracing of the farm was taken up. No special labour being engaged, the work was done in instalments and in the year 1923 the whole farm was made suitable for wet cultivation.

The Farm is situated about 5 miles from Mysore. It was established as part of the sugarcane development scheme, in the channel tract of the Mysore District served by the new Krishnarajasagara. The Farm consists of 60 acres made up of 45 acres of wet land and 15 acres of dry land. The situation being practically a low hill, the whole of the wet area has had to be laid into terraces, individual fields being only 1/20 of an acre in extent. The object of the Farm is to test the promising varieties of sugarcane evolved on the cane breeding section on the Hebbal Farm as regards their suitability to the Mysore channel area and to multiply such varieties and supply seed, serving thus as a *sugarcane seed farm*. Incidentally the farm carries out manurial tests of sugarcane, experiments on the cultivation methods chiefly a rotation of sugarcane and groundnuts instead of sugarcane and paddy experiments on the planting seasons, weekly growth measurements throughout the growing season and demonstration of jaggery boiling methods.

In addition to sugarcane, paddy is also an important crop on the farm, as it is of the whole surrounding country. Varietal tests

of district varieties of paddy have been continued and individual selections made from 11 of these varieties for further tests and multiplication.

Tests are also made of varieties of early maturing varieties of paddy suited to the main irrigation season of the tract.

A large variety of *manurial experiments on paddy* has been in progress for some years, *viz.*,—

1. the use of superphosphate alone and in conjunction with the green manures usual in the tract ;
2. the use of nitrogenous manures like sulphate of ammonia combined with supers ;
3. the use of oil-cake with supers ;
4. the use of ammonium sulphate with bonemeal ;
5. the value of basic superphosphate as against ordinary superphosphate ;
6. the value of the proprietory manure "Ammophos" of the grade 20—20 in comparison with sulphate of ammonia and super ;
7. the effect of varying proportions of nitrogen and phosphoric acid in the manure mixture ; and
8. the value of the lantana as a green manure as compared with sunnhemp and wild indigo.

As a result a manure mixture for paddy consisting of sulphate of ammonia and superphosphate has been largely advised in this neighbourhood. Superphosphate alone does not give profitable yields without the addition of nitrogenous manures. "Ammophos" gives very good yields and if it can be supplied cheap would prove a popular manure ; and lantana can be profitably utilized as a green manure for paddy.

Until the last year 1924-25, the arrangements for giving the farm a hot weather supply of irrigation water were not complete and consequently sugarcane was being grown under great difficulties. Nevertheless about 3 lakhs of setts of cane of the H.M. 544 and other varieties have been supplied to raiyats, who have taken seed setts to far distant places.

Practically the whole output of the paddy crop on the farm, especially the short duration varieties, is sold as seed to cultivators.

Among the medium quality varieties suited to the main season, the B.H. 24 and Coimbatore No. 1, both selections from Coimbatore Paddy Breeding Station, have been found very high yielders, though the grain is rather coarse compared with many of the local varieties.

Banku as a fine short season variety has given high yields on the farm and has been largely distributed.

The farm has also milled sugarcane for the *raiyats* of the neighbourhood in its power mill for a small fee in order to popularize the idea of co-operative ownership of a power mill and engine by the *raiyats* themselves. *Raiyats* were permitted to cart their canes to the farm and use the farm mill and boiling house.

The farm devised a cultivating tool for bullock draught combining a bladed hoe with an earthing up arrangement for work between rows of sugarcane, cotton or castor, so that hoeing and earthing up may be combined in one operation. On the small terraces, which do not allow of the use of bullock-drawn implements, the Planet Junior Hand Hoes are used for working between the rows of cane.

The farm has also introduced into cultivation the medicinal crop, *Baje "Acorus calamus"*, into this tract, which bids fair to be taken up largely by the *raiyats*.

The Babbur Farm.

The Babbur Farm is situated in the Hiriyur Taluk of the Chitaldrug District, in the tract irrigated by the (Marikanive) Vani Vilas Sagara irrigation system. It is also representative of the great black cotton soil country of that district on which the special crops grown are *jola* and cotton. The farm was therefore intended to demonstrate the cultivation of sugarcane and other irrigated crops on a large scale as a measure of development of that new area, and also to study problems relating to the cultivation improvement of the typical black cotton soil crops, cotton and *jola*. The tract is one of exceedingly poor rainfall, the average yearly rainfall being only about 18 inches. The area is also one where alkali patches abound, the trouble having also been aggravated by the new irrigation project. The problems facing the new farm are therefore peculiar to that tract.

The Farm comprises a total area of 200 acres, of which one hundred is irrigable while the remainder is all dry land. It is thus the largest among the Departmental Farms and the idea was to develop

it as a large commercial undertaking by the *growing, principally, of sugarcane on a large scale.*

The crops grown on the farm are sugarcane, Cambodia cotton, and plantains on the wet area and *sannahatti*—the local cotton and *jola* on the dry area. Sugarcane has been grown only over an area of from 20 to 30 acres, the principal reason being the unsuitable nature of the soil, which is wanting in depth and is greatly in need of drainage. A thorough system of open drains has greatly improved the soils after several years of continued attention and this served also as an object lesson to the neighbourhood. *Manurial and varietal tests on sugarcane* are carried on, the former indicating the need for cattle or organic manures for these soils which could not be altogether replaced by artificials though the latter in conjunction therewith have given greatly increased yields.

The varieties J. 33 A and H.M. 544 having done very much better than the local canes *Rasatali* and *Pattapatti*, these are being largely grown on the Farm and also distributed in the locality.

The Farm owns a *large power crushing plant* and a battery of three open pan furnaces for boiling down the juice into jaggery. Wood fuel has altogether been dispensed with and the jaggery boiling charges greatly reduced thereby. The whole arrangement serves as a demonstration of large-scale methods in the tract.

A large area was put under plantains more or less as a nurse crop to the young *cocoanut plants* of which a plantation is being raised. The cocoanut is becoming a popular crop in this locality, and this area on the Farm under cocoanuts was put down to study manurial, cultivation and other problems relating to that crop. A large number of varieties of plantains were planted and the result showed that the most profitable variety to plant was the "Poovan" of Coimbatore, the so-called choice varieties not proving suitable or at all as good as this variety. Cambodia cotton is grown as a bulk crop, from which the large seed supply for this tract is derived.

On the dry land, the most important work has been *breeding work* in regard to the local *sannahatti*. As the result of this work, Selection No. 69 has been evolved, which is superior in length, colour and uniformity of staple and ginning percentage to the local variety and also yields well under dry conditions. This variety has been

distributed largely through the District Staff of the western division, the area in the year 1925-26 being about 15,000 acres.

The farm is also equipped with a *large power gin*, in which all the farm cotton is ginned pure for seed purposes. A great deal of the *raiyats'* cotton is also brought to the farm gins and the return by way of ginning charges amount to a substantial sum in certain years. In 1923-24, the farm earned over Rs. 2,000 as ginning charges.

The farm also possesses an Austin Tractor and Tractor ploughs and disc harrow for work on the farm and for hiring out.

In addition, the farm has taken up the *breeding of cross-bred sheep* as experience showed these sheep thrive well on this farm ; the supply of cross-bred rams for *raiyats'* herds will be possible very soon from the farm herd.

The farm also maintains a stud bull for service to the surrounding villages.

Recently, *sericulture* has been started on a small scale and a special assistant appointed ; if the rearing of worms becomes a success on the farm, the prospects for an extension of this very profitable industry should be very bright.

Just in the same way as the other Government Farms, the sale of seeds of different kinds is a very large item of the work ; on the average a lakh of sugarcane setts, hundred maunds of Cambodia cotton seeds and 50 maunds of the selections and varying quantities of paddy and *jola* are being supplied annually.

The Balehonnur Coffee Farm.

This Farm which has been the latest to be started was sanctioned only in the year 1925. The circumstances of its origin and the kind of work proposed to be taken up may be briefly described here, principally as an indication of what the farm is expected to accomplish.

The investigation of the many and pressing problems relating to coffee cultivation — such as cultivation methods, manurial requirements, the testing of varieties, the breeding and propagation of high yielding or otherwise desirable varieties, the insect pests and fungoid and other diseases of the coffee—has been on the programme of the department from its very inception. As may be seen from the results of the work accomplished by the different sections, the chemical, mycological and entomological work on coffee problems has bulked very largely during the whole period and continues to do so

to an increasing extent. The whole of the work on these lines has had to be conducted only on the estates of planters who in spite of great inconvenience to themselves have cheerfully co-operated with the staff of the Department. It has been felt that a special Coffee Experimental Station completely under the control of the Department, with a suitable staff, resident on the farm, and proper equipment by way of a laboratory for scientific studies on the spot could alone ensure that amount of efficient attention that the coffee interests of the State really demand. The matter was gone into thoroughly both by the Mysore Department of Agriculture as well as the general body of coffee planters both in and out of Mysore, and with the co-operation and support of the planting community the opening of a Coffee Farm was urged upon the Government. One of the special features of the scheme was the levy of a special cess on all the coffee growing areas, from which the small planters owning not more than five acres were, however, exempted. This levy of the cess was finally decided by the Government after a great deal of consideration and consultation with the planters' representatives. The opening of the farm was duly sanctioned in the current official year and a sum of Rs. 30,000 provided in the budget.

The place selected for the farm is near Balehonnur in the Kadur District, the heart of the coffee region, with an elevation of 2,500 feet and a rainfall of 100 inches.

The area of the farm will be about 180 acres eventually. The preliminary work of clearing, making roads, construction of buildings, planting of nurseries and other work has only begun; a nucleus of bearing coffee on which experimental work can be taken up at once and carried on while the farm is itself being planted and brought into the bearing stage exists in the 15 acres of bearing coffee adjoining the farm which is a free gift to the farm due to the generosity of Mr. Crawford. It will be possible, therefore, to begin the actual work of investigation of various kinds immediately.

Other Farms Under Consideration.

Two other farms one a *cocoanut farm* in the Tiptur tract for the study of the cocoanut, and another a large sugarcane farm for growing sugarcane on a commercial scale to be located in close proximity to the Krishnarajasagara Dam are proposed to be opened at a very early date.

Sericulture in Mysore.*

By N. Rama Rao, Esq., b.a., b.l.,
Superintendent of Sericulture in Mysore.

Extent and Distribution of the Industry.

Mysore is admirably fitted by soil, climate and local conditions for silk production. The industry is at present practised over about a third of the area of the State, to the south of a line joining Chintamani, Siddlaghatta, Chikballapur, Kunigal, Mandya and Nanjangud, and is slowly spreading northwards. The sericulture of Kollegal Taluk (Madras Presidency) is a continuation and organic part of the Mysore system. There is practically no part of the State where climatic conditions do not admit of extension of the industry; the only limiting factor seems to be economic. The total area under mulberry is about 50,000 acres, the value of silk produced is over a crore of rupees, and the industry in its various branches supports about 200,000 families.

Mysore has a distinct race of silkworm which is polivoltine, and spins a greenish cocoon yielding a beautifully lustrous silk of excellent natural quality. The Mysore worm is hardy and highly resistant to disease, but is slow in arriving at maturity and a poor producer of silk in proportion to the food consumed, as compared with univoltine and bivoltine races. It is, however, one of the best polivoltine worms in existence.

Position of Sericulture in Mysore Industries.

Sericulture has an important place in the agricultural economy of the State. It employs that part of the labour of the home which is prevented by custom or feebleness from participating in the more strenuous work of the field, and also that part of the time of the *raiyat* which is left unfilled by the operation of the seasons. The utilization of factors which would otherwise go to waste is wholly a gain, morally as well as materially, and one may claim for sericulture all that is claimed for hand spinning of cotton, with this addition, that it is more profitable, as it turns to account certain differential advantages of climate and natural conditions.

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* Reprinted from "Agriculture in Mysore".

Nature of the Industry.

The great bulk of Mysore sericulture is *subsidiary* to agriculture. It is practised by small agriculturists, who, as a rule, do not employ paid labour, nor devote exclusively to rearing either time or house-room or other resources. They generally grow their own food, and depend on the returns from sericulture for clothing and condiments, and for the little extras which brighten their lives. But it must be mentioned that in parts of the State, sericulture has established itself as a *main* industry in successful competition with other occupations. This state of things is to be found in almost all the silk-producing parts of the State, in the vicinity of large markets, such as Channapatna, Chikballapur and Kollegal. In fact, in all important sericultural areas, there is a nucleus where sericulture is the principal industry. It may be noted that the same thing has occurred in Japan. This concentration seems to take place under the following conditions :—

(1) The soil is more suited for mulberry than for other crops ;

(2) the population is much greater than the soil can support if used for food crops, and there is in consequence necessity for a quick-yielding money crop which can remunerate intensive application of labour ;

(3) vicinity of large towns or important weekly bazaars affords facility for selling silk and buying foodstuffs and clothing ;

(4) there are no competing industries which draw off labour.

Sericulture practised as a main industry is rather more sensitive to external conditions than the normal form and is therefore the first to suffer from unfavourable variations. This is due to the fact that the competition of other crops with mulberry and of other occupations with the rearing of silkworms is never absent, and makes itself felt when, for some reason, sericulture begins to weaken.

Average Returns from Individual Undertakings.

The Mysore rearer has, on the average, half an acre of mulberry with which he rears six crops of silkworms in the year. He loses or used to lose about two of these crops owing to bad seed or inadequate knowledge and resources, but is able notwithstanding to make a net gain of about one hundred rupees a year. The average duration of a crop from start to finish is about six weeks. Apart from its undoubted material advantages, the industry necessitates a certain amount

of co-operation and evokes a mental alertness which is more akin to industrial than agricultural pursuits. A sericultural village has generally an air of life and prosperity all its own.

History of Sericulture in Mysore.

In spite of obvious advantages, the story of Mysore sericulture is one of vicissitude. In 1866 it had almost died out owing to disease or deterioration of silkworms, and was temporarily restored by the importation of Japanese seed. The root causes of decay however remained untouched, and one or two bad seasons upset this lightly built restoration. But the vitality due to favourable natural conditions enabled the industry to start with a new lease of life about 1890. It is significant that in this revival the imported worm had disappeared, and the Mysore worm emerged triumphant. Once again the industry declined, till in 1914-15, it reached its lowest point, with an acreage under mulberry of not much over 25,000. As a result of vigorous State action, the decline has been arrested and the growth natural to a healthy industry has been restored during the past ten years.

State Action.

Economic Conference, Agricultural Committee, Organization of Sericultural Department.—The efforts made to protect and develop sericulture are a measure of the growing recognition of its importance to the State. Not very long ago, the Education Department was entrusted with teaching sericulture through the agency of village schools with no great success. The subject was then taken up by the Economic Conference, and a few trained men were sent out for work to sericultural taluks. Each step rendered the scope for advance more obvious. In 1913, Signor W. Mari, an Italian Expert, was appointed to organize sericulture, but was able to remain only for a year, during which time he started a small farm at Channapatna, and made a beginning in the manufacture and issue of cellular seed. After Signor Mari's departure, the work was continued and developed by the Agricultural Committee of the Economic Conference, which did much to popularize disease-free seed and improve the methods of rearing. The causes of the decline of the industry were investigated and remedies proposed. The Committee's labours at this critical period in the history of sericulture proved that the situation was not

hopeless, and indicated the lines of useful action. In 1916 Signor Mari's services were engaged for a second time, and Mr. N. Rama Rao, an officer of the Mysore Civil Service who was Secretary of the Agricultural Committee, was associated with him for sericultural work. Signor Mari was only able to draw up a scheme before failing health and the outbreak of the Great War compelled him to return to Italy. Mr. Rama Rao was then appointed Superintendent of Sericulture in addition to his duties as Secretary of the Agricultural Committee. In 1920 the work had developed sufficiently to necessitate the organization of a Sericultural Department, and the transfer of the whole-time services of Mr. Rama Rao, Superintendent, the department being at the same time placed under the control of the Director of Agriculture. It secured and utilized to advantage, the services of Mr. M. Yonemura, a highly qualified Japanese Expert, for scientific work, and of Miss E. Sato for reeling. Later on it was possible to replace them by members of the departmental staff who returned from deputation with high technical training in Europe and Japan, or had been able to specialize by association with the Expert in scientific work.

Classification of Work in the Department.

The activities of the Department have been based on a close analysis of the structure and requirements of the industry. Investigation placed it beyond doubt that the instability of Mysore sericulture in the past was due to one or more of the following causes :—

(i) Bad or insufficient seed,

(ii) Faulty methods of rearing and reeling,

(iii) Bad methods of purchase and sale—resulting in "sweating" at each stage,

(iv) Want of economic stamina.

That this analysis is in the main correct, seems borne out by the success of the action based upon it. The work of the Department falls under the following heads :—

Education.

Expansion.

Improvement of seed supply.

Demonstration and advice—help in case of silkworm diseases.

Loans.

Formation of Co-operative Societies.

Establishment of filature and popularization of Mysore silk.

Improvement of reeling-machinery and methods.

Investigation of markets for silk.

Organization of the Department.

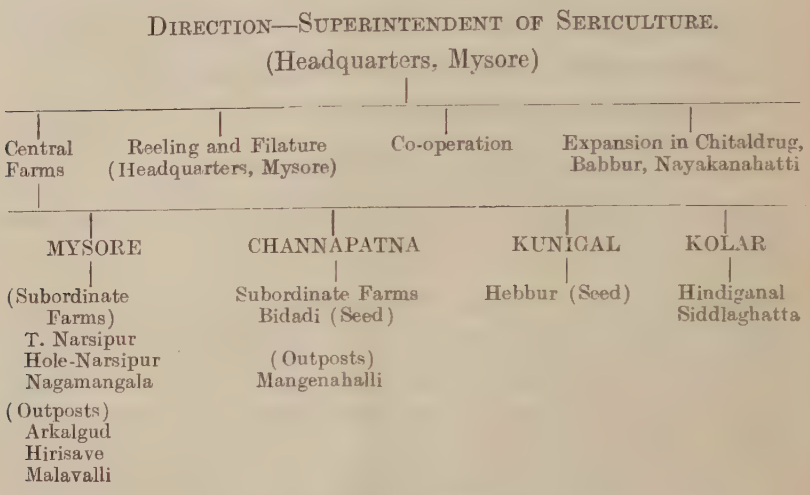
The organization of the Department for working out these objects is as follows :—

Circles, Farms, Outposts.—The sericultural parts of the State are divided into four circles, each provided with a well-equipped Central Farm capable of attending to all the activities of the Department in the area allotted to it. These central farms are in the charge of officers called Senior Inspectors, most of whom have high academical and technical qualifications. Each central farm controls a number of subordinate farms, located at strategic points so as to command the sericultural area. There are altogether ten such subordinate farms. Their function is to keep in close touch with the *raiyats* to secure them their requirements in the way of mulberry cuttings, silkworm seed rearing and reeling appliances, and loans, and to advise and guide them when necessary, to procure for them assistance such as disinfection, etc., in case of silkworm epidemics, and to render them generally all possible assistance in making the rearings a success.

In addition to the above, when work develops in a new area sufficiently to require continuous attention, outposts are established dependent on the nearest organized farm. These outposts are shifted from time to time according to requirement.

Special Branches—Filature and Reeling, Co-operation, New Areas.—The improvement of reeling and the filature constitute a separate Section under an officer entitled Superintendent of Reeling and Filature, with headquarters at Mysore : and the formation and care of Co-operative Societies is treated as a special branch of work, and has a Senior Inspector with headquarters at Channapatna to look after it. The expansion in Chitaldrug District is in charge of an Inspector, who at present works in direct subordination to the Superintendent.

The following statement shows the organization of the Sericultural Department :—



The total staff, exclusive of clerical, is—

6 Senior Inspectors—4 permanent, 2 temporary.

20 Inspectors—18 permanent, 2 temporary.

30 Operatives { 1st class 10. / 2nd class 20.

The work done by the Department under the various heads of activity is summarized below :—

EDUCATION.

Year	Education.
1919—20	16 Long course students.
	6 Short course students.
	26 Panchamas.
1920—21	4 Higher course.
	11 Lower course.
	24 Short course.
	33 Panchama students.
1921—22	10 Long course (mostly volunteers).
	20 Short course.
	11 Panchamas.
	26 Students in Taluk Schools.

1922—23	8 Long course. 14 Short course.
1923—24	No regular course for want of funds. Yet 20 students in lower course and 3 in higher course were trained. One of the three was from Hyderabad and two from Coorg. The Farm School trained 10 people.
1924—25	10 Higher course. 10 Lower course. 5 Short course in Mysore. 4 Short course in Channapatna. 6 Short course in Hole-Narsipur.
1925—26	77 Students including 22 in reeling.

Till last year an allotment was usually sanctioned for scholarships in the Budget of the Department, and it was possible to train men for recruitment. The District Boards have always been very generous in giving stipends to students from their districts, and have evinced great interest in the encouragement of the industry. Students trained by District Boards have invariably settled down on their own lands. It is getting increasingly difficult to find recruits for the Department, for want of trained men, and owing to the very low rates of pay allowed to Operatives.

Every Farm of the Department is a school for practical instruction, and profoundly influences rearing methods in the neighbourhood.

In co-operation with the District Board of Mysore and the Education Department, Sericulture has been introduced as an examination subject in two selected Middle Schools at Kuderu and Malavalli. The District Board of Hassan has also sanctioned the opening of a sericultural class on the same lines at a place to be selected shortly.

Expansion.

Exact statistics of mulberry cultivation are not available. Our ideas of fluctuations in area have to be based on the figures in the Season and Crop Reports, supplemented by direct information and verified by first hand general impressions. The export trade in silk

furnishes an index of the state of the industry, and the demand for mulberry cuttings and for seed cocoons furnishes another indication. There is no doubt that the industry has been growing by expansion to the north of the old frontier, and that a corresponding strengthening has been going on in the old areas. The years 1923-24 and 1924-25 were bad years, owing to scanty rainfall and low prices, and in some places—specially where sericulture had become a main occupation—there was an immediate diminution in the area under mulberry. That the industry did not suffer more severely is due partly to its natural robustness, and partly to the slowness with which causes react on a conservative population. There is however no doubt that to-day the industry has grown to nearly twice the size it was in 1914-15, and that deep-seated sources of danger have been eradicated. In estimating the scope for expansion, there is practically no part of the State where the climatic conditions are such as to preclude the industry; but regard must be had to the economic conditions favourable to its introduction. There are parts of the State where population is so sparse that agriculture and even domestic service are dependent on imported labour: introducing sericulture here is out of the question. There are other parts where wages are high owing to the existence of large centralized industries like mills, mining, factories, and work-shops; and others again where there are already suitable subsidiary industries, which it would be inexpedient to disturb. Large sections or communities have religious or sentimental objections to one or more stages of the industry: and this prejudice, where it exists, presents a fairly formidable barrier to expansion. Allowing for all this, there is no doubt that the sericulture of the State can be developed to about four times its present size, without interfering with any other avocation, but merely by utilizing resources which now go to waste. The increased output could easily be absorbed by India, which at present imports about seven crores of rupees worth of silk and substitutes either as yarn or as fabrics. This forecast assumes, of course, that nothing will occur in the meantime to curtail the world's demand for natural silk, and that the distance between silk and rayon and other textiles will remain more or less what it is at present. This is by no means an improbable assumption. The relative position of natural silk and rayon will be referred to, again, later in the report.

Seed Supply.

Cellular Seed.—The development of this section of work furnishes a measure of the growth of the Department in influence and usefulness. Ten years ago, the rearers could, with difficulty, be persuaded to take 200 layings a year. In 1925-26, we produced 401,056 layings in our grainages, and procured, through our selected rearers, the production of nearly 70 lakhs of seed cocoons raised with cellular seed; and yet only a part of the demand was met. To produce this quantity of disease-free seed, the grainages strained their resources to the utmost; and it is probable that the limit with our existing equipment has been reached. The demand is so strong that if we quadrupled our production we could hardly satisfy it. A feature of the present demand is the eagerness of the *raiyats* for the new races. These new races and hybrids, which are a result of our experimental and breeding work, represent an increase in yield of nearly 40 per cent and a curtailment of the period of rearing by 4 to 5 days in its most expensive part. To produce seed of these races on an adequate scale, it is necessary to have a cold storage plant, with which the Department has yet to be provided.

Some idea of the value of this branch of the Department's work can be formed when it is said that whereas formerly 2 crops used to be lost out of every 5 owing to bad seed, failures from that cause are now comparatively infrequent in areas reached by our seed organization.

Selected Seed Rearers.—A word of explanation is necessary about selected seed rearers. Since cellular seed is expensive, and its supply is very limited, it is necessary to supplement the work of grainages—which turn out only cellular seed—by a carefully planned and controlled campaign of seed production with the co-operation of selected rearers in the recognized seed centres. The basis of selection is a good mulberry garden, a disinfectable rearing room, and skill and reputation on the part of the rearer. The selected seed-man has to bind himself to rear only cellular layings issued to him from the Government grainages, and to submit to supervision and control. He gets the cellular seed free of cost, his rearing room is disinfected, and he is placed in touch with the great body of rearers requiring seed cocoons. We have now 47 seed rearers in the far-famed seed centres

of Bidadi, Kunigal and Hebbur, capable of producing in the aggregate about 70 lakhs of seed cocoons. Mention must be made of a very notable piece of intensive seed work conducted last year at Mugur, one of the largest silkworm rearing villages in the State. Three consecutive crops had failed owing to pebrine. The Department organized a systematic disinfection of rearing houses. and supplied cellular layings to all rearers. *Not a single crop failed.*

The following figures show the growth of the seed work of the Department :—

1919–20	..	180,297 D.F.* layings distributed to *raiyats.*
1920–21	..	277,862 D.F. layings were issued.
1921–22	..	326,193 D.F. layings and 27 lakhs of seed cocoons through Seed Cocoon Campaign.
1922–23	..	395,959 D.F. layings and 60 lakhs of seed cocoons.
1923–24	..	240,901 D.F. layings and 90 lakhs of seed cocoons. and 9,000 D.F. layings of New Races. (Very unfavourable season.)
1924–25	..	390,168 D.F. layings (including 12.000 of New Races) and 70 lakhs of seed cocoons.
1925–26	..	401,056 D.F. layings and 68 lakhs of seed cocoons.

Demonstrations. Improvement in Rearing. Treatment of Silkworm Epidemics.

What with the improvement of the seed supply and what with the example and the educative influence of the farms. the Mysore *raiyat,* especially in the vicinity of the departmental institutions. now gets a yield which represents a substantial improvement over what he used to get in the past. Ten years ago 25 to 30 lbs. was considered a fair yield for a rearing with 100 layings ; the present average is somewhere about 40 lbs. The record yield got anywhere was 89 lbs. for 100 layings of a F1 Hybrid near Channapatna. The improvement consists in better spacing. a more suitable adaptation of food to stage of development. more efficient methods of cleaning. some attention to silkworm hygiene and greater care in mounting and harvesting. A very large number of demonstrations accompanied with lantern lectures are held every year at important *jatras,* festivals, or other large gatherings of people with the help of District Boards.

*"D. F." means Disease Free.

Competitions are arranged between improved machinery and the old-time village appliances, and many a convert to rational sericulture has been secured. There were two large Sericultural Conferences at Channapatna and Mysore, held by the District Boards of Bangalore and Mysore respectively, where a number of important resolutions were passed which are now under consideration. The District Board of Mysore, the premier silk-producing district of the State, co-operated very cordially with the Department by giving sericulture a prominent place in all their Conferences and extending to it a very generous measure of encouragement and assistance.

Loans.

As has already been stated, the small rearer has not much economic stamina, and is frequently in need of loans for short terms. He was formerly at the mercy of small money-lenders who practically squeezed him dry; and then, as frequently happened, the money-lender was also a buyer of cocoons, the rearer rapidly lost freedom of sale, and fell into a position of dependence. There are two obvious remedies—State aid through *takavi* loans, and the organization of co-operative credit. Real co-operation suited to the industry is of slow growth, and as will be stated later, a sound and promising beginning has been made. Government have sanctioned a scheme of sericultural loans also; in practice, these loans at present provide for long-term credit for capital expenditure, while short-term loans are as a rule left to co-operative and private credit. Formerly the administration of these loans was entrusted concurrently to local revenue officers and the Superintendent of Sericulture; the revised rules of 1925 vest this responsibility solely in the Sericultural Department. The following statement sets forth the amount of loans granted each year :—

Year.	No. of loans.	Amount.
1916—17	.. 27	Rs. 3,060
1917—18	.. 11	,, 920
1918—19	.. 3	,, 450
1919—20	.. 4	,, 950
1920—21	.. 21	,, 4,880
1921—22 1922—23 1923—24	Information not available. Loans were granted under old rules by Revenue Officers.	
1924—25	.. 10	Rs. 2,830
1925—26	.. 39	,, 7,450

Co-operation.

There is no doubt that sericulture offers an almost ideal field for co-operation, and yet strangely enough, till last year, there was not in existence a single Sericulture co-operative society. One had been started by the Co-operative Department some years ago at Sidlaghatta, but it failed. It was obvious that existing types of society would not do, and that the industry required a distinctive type, combining short-term credit with supply of seed and appliances, technical guidance, and aid in marketing. The work of such a society is sericulture first, and co-operation afterwards: and close and constant technical direction is essential. A type of society suited to Mysore sericulture was worked out. Government approved of the scheme, and sanctioned a special Senior Inspector for working it. They placed a sum of Rs. 2,800 with the Registrar of Co-operative Societies for being advanced to sericultural societies. *Ten* societies were formed during the year in the following villages, which were prepared for the development by careful propaganda :—

(1) Mangalwarpet	(6) Sidlaghatta
(2) Malurpatna	(7) Thimmasandra
(3) Chakkere	(8) Kudlur
(4) Mogenhalli	(9) Mugur
(5) Closepet	(10) Karohatti

Most of these societies have started very well, and show great willingness and aptitude, but have more than justified the anticipation that close and constant technical guidance is vital, at least in the initial stages.

Filature, Village and Domestic Reeling.

A small filature of 12 basins of the French type was installed in Mysore in 1922. The object was to train labour, experiment in reeling technique, test the reeling quality of cocoons, and familiarize the silk world with Mysore sericulture. This filature started with exporting silk to France and England, and is now devoting itself to the manufacture of high grade silk capable of utilization in Indian weaving. It is slowly educating the Indian demand, and preparing the way for grading up the quality of Mysore silk as a whole. It would be very useful if the filature were supplemented by a small throwing

mill and a weaving establishment. The filature is capable of producing about 300 lbs. of silk a month.

A filature, equipped also with a throwing plant, has been established by private enterprise at Bangalore.

Village and Domestic Reeling.—Filatures have undoubtedly an important part to play in raising the industry by giving a lead in the improvement of reeling, and by preparing the way for superior silk by advertisement and securing a demand; yet the country's silk as a whole, can only be benefited by gradually improving the equipment and methods of the village reelers.

Last year experiments were conducted with various types of domestic basin; demonstrations were organized on a large scale, and constructive criticism was invited from all eligible quarters. The result of the investigation may be summarized as below:—

(1) It is essential to the development of Mysore Sericulture and even to its stability, that the quality of the raw silk produced should be improved and made uniform, so as to extend the scope of its employment in manufactures. At present, its low quality confines it to a narrow and comparatively unremunerative market.

(2) Conditions in Mysore make it imperative that this improvement must commence in the villages in close touch with the rearing industry; and it cannot be imposed from outside by the establishment of filatures. The improvement of raw silk is dependent on the improvement of cocoons by the provision of good seed and employment of better rearing methods on the one hand, and the introduction of more efficient reeling machinery on the other. In Mysore, reeling cannot, without disaster, be dissociated from seed production and rearing.

(3) The reeling machinery should satisfy the following conditions:

(*a*) It must possess all the essential working parts of the latest type of filature basin which ensure proper size, strength and cohesion.

(*b*) It must be strong, simple in construction and capable of being attended to by the village smith with his ordinary resources.

(*c*) Its initial cost must be within the means of the average village family; its working should demand no special

skill or expense, and it should exact no requirements in the way of furniture.

(*d*) It should be portable, and should lend itself to gradual expansion by the addition of fresh units, securing fresh economies with each expansion.

(*e*) While not inferior in efficiency to the best foreign basin, it should compare favourably with the village *charka* in cheapness of operation and adaptability to rural conditions.

Mysore Domestic Basin.—It is obvious that (*b*). (*c*). (*d*) and (*e*) put the foreign basins out of court at once. To satisfy these conditions, a basin was designed and patented under the name of the "Mysore Domestic Basin". This basin can be worked either singly, or in combinations consisting of two or more. Probably, five form the most advantageous combination, as they can be operated by a single turner. They have been successfully tested throughout the State, and have invariably elicited great interest and enthusiasm during demonstrations. Silk reeled with the domestic basin is nearly as good as filature silk, and fetches prices fully 30 per cent higher than silk produced with the village *charka*.

Experiments.

Important experiments in silkworm breeding are being conducted in the Central Farms at Mysore and Channapatna, covering practically the whole field of sericulture. In breeding, the main objects kept in view have been :—

(1) selective improvement of the Mysore race of silkworms,

(2) fixation of new races,

(3) determination of the extent to which hybrid seed could be profitably issued for producing reeling cocoons,

(4) rearing and acclimatization of pure races for stock in the preparation of hybrid seed.

Besides the progress made towards the objective, the experiments were fruitful in results of great scientific interest. The experiments were only made possible by a free and successful employment —for the first time in India—of the artificial treatment of hibernating eggs so as to make them hatch like multivoltines.

The experimental breeding work disclosed some important facts. The limits of improvement by selection in the pure Mysore race itself

are in sight : it is not possible to shorten the rearing period, or to secure a more profitable ratio between the yield of silk and the consumption of mulberry leaves. The experimental work has been rich in results of great value to the industry, but to take full advantage of them, it is necessary to have more grainage and rearing space, more staff and facilities for controlling temperature. The rearers are anxious to rear the improved seed and seed of higher yielding races, but the department is not at present equipped to meet the demand.

Organization.

Sericulture has its roots in the economic life of the country and is necessary to its progress and happiness. Improvement of seed and technical methods would be barren of result without an organization that secures to the workers the full benefits of their labour. No industry can prosper without a power of adaptation to changing conditions and without the capacity to assimilate new ideas. Its progress depends on the readiness with which it can benefit by the advance of knowledge, and this requires alertness and power of internal adjustment, or in other words, a broad-based organization which can keep abreast of technical progress, and which can safeguard the industry by influencing production, and by securing an appropriate place in markets. The organization must begin in the village, with a co-operative society or panchayet ; the co-operative societies, panchayet and leading sericulturists of a taluk may form a Taluk Association, and the process of federation may rise through taluk and district, till it culminates in a Central Silk Association for the State, capable of representing the industry and looking after its interests. Steps are being taken, with the approval of Government to form a Provincial Silk Association, which will probably have ramifications extending into taluks. It is necessary also to have a Conditioning House in the State.

Summary of Past Work.

The chief measures for which the department has been responsible are :—

(1) Organization of Government grainages.
(2) Organization of aided grainages.
(3) System of selected rearers of seed cocoons.

(4) Organization of supply of mulberry cuttings to aid expansion.

(5) Organization of practical instruction to new rearers and reelers.

(6) Provision of sericultural loans.

(7) Concessions for introducing sericulture in new areas and among the depressed classes.

(8) Establishment of filature.

(9) Designing new types of basin for Mysore conditions.

(10) Establishing new races and breeds of silkworm.

(11) Organization of co-operative societies.

(12) Securing co-operation and assistance from Local Boards.

(13) Investigation of South Indian markets.

(14) Concessions for the formation of mulberry *topes*.

(15) Introduction of sericultural instruction in two middle schools, in co-operation with the Education Department.

PROGRAMME OF WORK FOR THE FUTURE.

The programme of work for the future will not only have to maintain progress on the lines already established, but will have to provide for the following important developments :—

(1) Establishment of cold storage plant in the Central Farms.

(2) Investigation of the requirements of Indian silk manufacturers and adoption of Mysore raw silk thereto.

(3) Organization of trade, and the establishment of suitable centres of distribution.

(4) Standardization of Mysore silk and establishment of a Conditioning House.

(5) Formation of local silk associations which are in quick touch with all branches of the industry and their affiliation to a Central Provincial Silk Association.

(6) Development of sericultural co-operation so as to embrace every part of the industry.

(7) Legislative control of seed production and of epidemic diseases.

(8) Protection for Mysore silk.

This work has been, and is being done in Japan, and is equally necessary here. The work requires more staff and more equipment and is of a magnitude to tax the energies of the Department for the next twenty years. Later on, it may be possible to transfer some of

the functions to local bodies retaining only scientific work and control in the Department.

Conclusion.

There is evidence of an essential change in the outlook of the Mysore silk industry. Till quite recently, we were in secure possession of the South Indian market which took our average saleable output, however coarse, provided only it was cheap. The combination of cheapness and badness held our industry in thrall, but kept it alive. Now things are changing. Better reeled foreign silks, and artificial silk and with its cheap glitter irresistible to the untutored eye have invaded the traditional markets, and are fiercely competing with Mysore silk. One usually reads in foreign Journals that artificial silk—or rayon as it is called—can never displace natural silk, and so on; and this is no doubt true, but with two important provisions—*viz.*, (1) the natural silk must be a high grade article, like what is imported into Europe and America, (2) the consumers must possess sufficient enlightenment to know what they are buying, and to know both what artificial silk is and what it is not. In India where much of the natural silk is reeled in a low grade, and where a large proportion of the consumers look upon rayon as a durable foreign silk, possessing the advantage of cheapness, rayon *does displace and is displacing* real silk. In the long run, a better knowledge of rayon may confine its employment within just bounds: but it is possible that this knowledge may come too late to save Mysore sericulture from irremediable injury. There is evidence that in Mysore, the very home of silk, a large proportion of the looms which formerly employed only real silk, now take rayon, and the rayon fabrics are penetrating into middle class homes. Usually, bad seasons, by contracting the output of silk, raise its prices, but last year the industry suffered from the double evil of bad season and low prices. There seems to be no doubt that one of the causes of this abnormality is the increasing vogue of rayon. One has only to know that the imports of rayon into India have increased from 19.4 lakhs of rupees in value in 1922 to 204.35 lakhs of rupees in 1925 to realize the magnitude of this menace to our silk industry. The world's production of rayon in this period has grown from 79.3 million pounds to 185.5 million pounds; and much of the accumulated capital and disciplined skill of some of the most progressive countries in the world are being devoted to increase, improve

and cheapen this product. With proper direction and improvement the natural silk industry ought to rise above the plane of direct conflict with this giant organization by producing a high class fibre which supplies a distinctive demand which will not accept a substitute ; but in a cottage industry practised by the *raiyat* classes, adjustment to new conditions is a very slow process indeed, and in the meanwhile the industry itself may suffer lasting harm. Experience shows that our *raiyats* are very tenacious of sericulture so long as any hope is left ; but once they are driven from it, nothing will induce them to take it up again. In fact the places where sericulture once existed but exists no more, seem blighted with a curse against revival. The reason is, that each acre which goes out of mulberry is a loss in capital alone of over a hundred rupees, and the wrench in economic life resulting from the loss of an established occupation paralyses the spirit of enterprise. And this is a loss which falls on a specially poor and hardworking class of people.

There can be no doubt that our silk needs protection against foreign silk and more specially against rayon. This is not the place for discussion of the subject ; it may suffice to say that the Board of Agriculture recorded it as their considered opinion that :—

"In view of the growing menace to the silk industry from the competition of foreign silk and silk goods on the one side, and of artificial silk and artificial silk goods on the other, it is essential that strong measures should be taken for the protection of the industry."

Apart from this, it is equally essential that Mysore should produce cocoons at less cost by employing better seed and improved methods, produce better silk by employing more efficient and up-to-date machinery, and standardize production by adapting it carefully to markets. All this is necessary not only for improvement but for survival. A Silk Association with ramifications reaching out into taluks and centres of production and a State Conditioning House seem absolutely essential to safety.

SELECTIONS.

I

Danish Farming.

Comparisons between the farming methods of different countries are always difficult, and are almost bound to lack precision because of differences in the basic principles underlying practice. References to Denmark have been made almost time without number during the last forty years, because her agriculture has been regarded as so phenomenally successful. It may perhaps be said, however, that this country has not yet fully apprehended—in the sense of putting it into practice—the lesson that Denmark can teach.

At a meeting of the Royal Statistical Society on 19th January, Mr. R. J. Thompson, C.B., read a paper in which he made some fresh comparisons between the productivity of British and Danish farming in an entirely novel way, and raised some very interesting and fundamental questions as to the reason for the marked difference which is believed to exist between the two countries. The conclusion arrived at by the statistical comparison is that the average output per 100 acres of agricultural land is over 50 per cent higher in Denmark than in Great Britain, after deducting the feeding-stuffs, seeds, and fertilizers which contribute to this production. The explanation of this high figure is stated to lie mainly in the fact that as compared with Great Britain, Denmark carries a heavier head of stock in combination with a high arable area, and by growing crops on this arable area feeds this stock to a greater extent from her own soil. This is combined with a higher yield per acre in the case of certain crops, with a larger yield of milk per cow and with a larger output of eggs and poultry.

Taking those facts as a broad general conclusion, Mr. Thompson proceeded to examine the comparative costs of production, including wages and persons employed the object being to determine whether there is any obvious explanation of the higher productivity of Denmark. While there does not appear to be any very serious or material difference in these respects between Denmark and Great Britain, it may well be that costs of production in Denmark are really and effectively lower than in Great Britain owing to the co-operative purchase of feeding-stuffs, etc.,

to greater personal labour on the part of the farmer, and also to the fact that though cash wages seem to be much the same in both countries, Danish labour may be cheaper owing to longer hours and greater efficiency.

The real crux of the problem, however, lies not in the gross or net output, or even in the costs of production, but in the net return or profit to the producer. Whether the British farmer is, or is not, securing from the soil as great a quantity of produce as is obtained by farmers in other countries, he is presumably producing as much as it pays him to produce at current prices. This leads to the question, if a large gross production and a large arable acreage tend to the agricultural prosperity of Denmark, why is not the same system applicable to this country? To this there is no simple answer.

Apart from the question whether costs of production are really and effectively lower, Mr. Thompson thought that it is quite possible (1) that the Danish farmer produces on the average a higher grade of article and thus obtains a higher price; (2) that by improved methods of marketing and organization he obtains a large share of this price, thus securing a larger average return on his total production; and (3) that on the average he may be content with a smaller cash profit, or, alternatively, may be willing to work harder or more energetically to secure a similar return.

In this connection the size of the farms may have an important bearing. In Denmark, some 56 per cent of the cultivated area is in farms of between 37 and 128 acres. In England and Wales, some 53 per cent of the area is in farms of 150 acres and upwards. There is also the factor of ownership to be taken into account. The British farmer on the whole regards his farm as a money-making machine in which he invests such capital, labour, and enterprise as he expects will give him a satisfactory cash return. The Danish farmer, on the other hand, is more attached to his holding, and more inclined to look to the average result and to the long-period increase in the capital value of his farm. The mere fact that he is the owner encourages him to put more capital, more labour, and more enterprise into his undertaking over an average of years than the British farmer.

The conclusion to which Mr. Thompson finally comes is that it is the smaller size of the holdings, combined with the psychological effect of ownership, to which the main difference in the agricultural systems of the two countries is due.—*The Journal of the Ministry of Agriculture*, Vol. XXXII, No. 11.

II

Curing of Coffee.

The correct curing of coffee to the novice or the slipshod planter appears an elaborate process, but in reality is a simple process and easily acquired, and if persisted in becomes second nature. A strict adherence to small details is essential to success, and the non-observance of apparently little things has led to the failure and disappointment of many.

Coffee may be cured in three ways, *viz.* : "Parchment," "Chum," and "Wholeshell," but there is only one process which will secure you the top price, and this is by the system known as Parchment. All three systems require the berries to be gathered cherry ripe.

To produce the best parchment coffee I recommend the following process : A fair supply of clean soft water (rain water in preference, collected or stored above the pulper and allowed to run by gravity into it), a pulper either native made or imported, a fermenting as well as a washing cistern, constructed of wood or cement, if of the latter the surface must be rubbed smooth to prevent the abrasion of the parchment the sizes depending on the quantity of pulped coffee to be handled and the amount of water available ; if plenty of water, the larger the washing cistern the better ; the fermenting one should be kept to a size to allow the heaping of the pulped berries ; next a wooden rake for stirring the coffee while washing it, and last a smooth barbecue or barbecues faced with either good lime mortar or cement, but better still one constructed of well cured hardwood lumber ; the boards must not possess any pungent or distinctive o lour, such as cedar, mahoe or pitchpine, as the natural aroma of the cured sample will be affected for some time until by the effect of weathering of the boards they lose their odour.

Each day's picking should be pulped the same evening, falling into the fermenting cistern where it is allowed to remain in a heap for at least 48 hours. If the weather be very cold, it will be found necessary to let it remain some time longer, at any rate until sufficient heat is developed in the centre so that you can insert your hand without undue discomfort ; it is well to turn the heap occasionally, *i.e.*, about once each 12 hours, so that all the berries may get the same amount of fermentation.

The cistern must contain an outlet to allow all surplus water to escape from the heap, otherwise a very slow and poor fermentation will take place. I have often seen the freshly pulped coffee totally submerged in water and allowed to remain there overnight : this is an incorrect procedure, as sufficient heat cannot be developed to set up an active fermentation, the only means by which the full aroma of the finished

produce can be attained. After thorough fermentation, transfer the "beans" to the washing cistern and totally immerse in clean water, in fact the water should be 4 to 6 inches above the level of the mass. Allow the beans to remain a few hours in the water, then stir well with the wooden rake, renewing the water 3 or 4 times until no "gummy" matter remains adhering to the parchment. Before running off each lot of water skim off all light beans and bits of skin floating on top, keep all these skimmings and cure separately from the main lot. After this washing operation is completed and the water thoroughly drained, remove to the barbecue and start drying.

Particular factors to remember in drying parchment coffee are these—never allow it to get wet after being once partially dry; next, it must be dried slowly; this slow drying brings out, and allows the cured berry to retain the "blue" colour so desirable in good coffee; it also fixes the aroma to a great extent. A very hot barbecue is detrimental. Four to five hours per day of medium sun until the coffee is three-quarter dry is the procedure advised; after that it may be dried more quickly: once it is thoroughly dry it will not be again affected by very hot sun.

It is not possible to obtain a good sample of coffee if dried in an "earth" barbecue, the earth transmits to the berry an extraneous aroma which can never be eradicated, neither should it be dried or stored near smoke or any article having a distinctive odour, such as tobacco, pimento, annatto or salted fish stuffs. Coffee will permanently assimilate any such foreign odours, and transmit it to the concocted beverage.

The advantages of curing coffee in the parchment are as follows: It is the only form of curing which will give you the true aroma; it can be dried in a shorter period than any of the other methods: as soon as the water which adheres to it after washing is dried off, it can be taken off the barbecues and stored away at nights to avoid the depredations of thieves; when partially dried it may be stored for weeks if unfavourable weather prevails, and lastly, if properly cured and of a good quality, sells for a higher price than that cured by any other method.

"Chum" is prepared as follows:—The cherry ripe berries after being brought from the field are placed in heaps on the barbecue, in boxes or barrels and turned each day until the outer or "cherry" skin by fermentation becomes partially decomposed; portions of the resultant mass should then be placed in "mortars" and beaten or pulped. After you have examined and found that the greater portion of the outer skins have separated from the "parchment", wash and treat in the same manner as advised for the curing of parchment.

"Wholeshell" is treated in the same manner as "chum" after removal from the field, but no pulping or subsequent washing is performed after fermentation. It may be immediately spread on the barbecue, and there left exposed to thieves, wind and weather, until about three-quarter dry, if at this stage it has escaped the attention of these, continue drying at your leisure on each favourable occasion until perfectly cured.

There are serious objections to "chum" and "wholeshell" coffee; They take longer to "cure" than "parchment", never attain that permanent dark greenish blue colour so desirable in a well-cured sample, and under the most favourable conditions retain to great extent the acrid aroma transmitted to the "beans" by fermentation in conjunction with the outer skins. This is more marked in "wholeshell" and is coupled with a musty flavour. The process of "peeling" wholeshell is also laborious and costly. Only those who have tested really good parchment coffee in opposition to good wholeshell, can judge what a vast difference there is between the two methods of preparing, *i.e.*, for the market. Coffee to be really good must be thoroughly dried, *i.e.*, until it breaks sharply when bitten between the teeth; it cannot be stored after being peeled for any length of time without the colour becoming much paler (sometimes nearly white) if not thoroughly dry, neither can you get a good sample if the drying process is forced over a fire as is often done by the unscrupulous dealer.

Preparing for Market.

A ripe coffee berry consists of the following component parts:— The outer covering or envelope is of a bright cherry red colour and generally contains two fully developed "beans", next comes the parchment which is separated from the outer skin by a gummy or mucus substance which allows the cherry skin to be easily pulped off when quite ripe; each bean is enclosed in its own parchment. Next under the parchment is the "silver" skin, closely adhering to the bean and takes a considerable amount of abrasion to remove it; under that is the bean or marketable produce.

The local trade will purchase coffee in the parchment, chum or wholeshell, of course, at a less price than for the finished product. Clean coffee to fetch the highest price must be divested of all the coverings and the silver skin entirely removed by polishing. To attain this end the small producer after warming in the sun, beats his dry parchment, chum or wholeshell in a mortar, until by friction the coverings are removed; the beans are then separated from the trash by winnowing. The larger grower grinds his in a mill specially made for the purpose, and uses an

imported fanner for removing the trash. The largest and most up-to-date planters and merchants use imported hullers (which at the same operation also polish and separate the trash) and graders.

All coffee before being sent to the local market should be "picked", *i.e.*, all particles of trash remaining, malformed, small, broken and discoloured beans should be separated from the perfect ones ; these pickings (without the trash) are called "Triage," and can be marketed or used for home consumption in conjunction with the "skimmings". The price paid for triage is very much below that obtained for a good clean sample. The ordinary grower "picks" his product by hand labour ; the large producer or merchants by expensive power-driven machinery, called graders.—*The Journal of the Jamaica Agricultural Society*, Vol. XXX, No. 6.

III

The Technique of Rice Growing in Japan.

The following article on "The Technique of Rice Growing in Japan" by Dr. J. S. Gramer, Director of the General Experiment Station for Agriculture, Buitenzorg, Java, is taken from *Communications* (No. 22) *of the General Experiment Station for Agriculture*. These notes have been gathered by the Editor during a voyage in 1924.

The dense population and the relatively small area of agricultural land forced Japan to concentrate all her forces on raising the yield per acre. With farms averaging three acres in extent the agriculture is perforce extremely intensive. In order to provide even the barest necessities for a family, such an amount of labour and attention must be given as will bring the crop as nearly as possible to the maximum (*Buchanan*, p. 550). In many respects the rice growing in Japan makes the impression of being carried on with more intersive methods than in countries like Java and Cochin China. During my visit in the end of June the farmers were just busy with planting their fields ; it was a striking feature that the young seedlings were always planted out in absolutely straight lines, along ropes made out of rice straw, or with the aid of a bamboo frame which was transplaced regularly. According to the information I could collect from colleagues in Japanese experiment stations more labour is spent on the upkeep than in Java ; *f.i.* more weedings are applied. Often the fields are weeded five times during the growing season. Already since old times manures are applied to the fields.

The irrigation is given, like with us in Java, mainly from rivers. According to statistics in a pamphlet on agriculture in Japan published in 1914 by the Department of Agriculture in Tokyo, the figures for the source of the irrigation water are :—

From rivers	65.4 %	of the area of paddy fields.
„ reservoirs	20.9%	„ „
„ ponds and lakes	0.9%	„ „
„ wells	1.3%	„ „
„ sources	5.4%	„ „
„ other means	6.1%	„ „

In Southern Japan I saw often dams in the rivers. They are generally constructed from stone blocks, cut into rough square form, and not of round boulders, kept together by wire netting as with us in Java.

Fesca calculated the quantities of water needed per cho ; he came to an average of 2-4 metric tons per day per cho, what comes near to the figure considered an average in Java, *viz.*, 1 litre per second per bahoe (0.7 H.A.). A difference with Java is, that the water of the rivers—at least of the ones I saw in June, in Southern Japan—is generally clear.

To bring the irrigation water on the field often paddle wheels are used, taking the water from the tertiary ditches. The paddles fit into a gutter through which they press the water up to the opening above, from where it flows on the field. The moving power is generally a man ; in the early morning, already at half past four, one sees everywhere men, their clothing reduced to a small girdle, busy with these irrigation wheels ; they tread upon the paddles on the side turned from the field, walk so to say upward on the wheel and give it a motion, which brings the water on the field. In the neighbourhood of Osaka I saw many small windmills in the fields the wings made out of zinc plate somewhat curved to catch the wind : they actioned small pumps, which pumped the water on the fields. Even sometimes one sees people irrigating vegetable gardens with water, hauled in buckets out of wells.

The working of the soil is not the point the best cared for in the culture. Ploughing is now far more general than in Fesca's time when it was a rare exception. The number of draft animals seems to increase. In some regions horses are used on a large scale. So I saw many used in the neighbourhood of Shimononseki ; in other regions the ploughs and harrows are drawn by oxen. During my visit in the end of June the harrowing was in full swing. By counting the number of people working in the fields, busy with seedling beds and planting out, and the number of draft animals, drawing harrows, I came to a proportion of 1 animal to 4-5 people. This leads to a comparatively strong density of horses and

cattle. In the opinion of some of the Japanese experts the number of cattle is increasing more than that of horses, because the first mentioned have also still some value for slaughtering. As prices for both, I heard, figures of a couple of hundred yen for an ox, for horses 300-500 yen. The last are mostly raised in Northern Japan ; they are much higher than the ponies we use in Java for carts. For us, who are not accustomed to see horses used before the plough in paddy fields, it is strange sight to see them plodding through the mud of the irrigated soil.

For ploughing, which is done only once before the rice is planted, the old-styled Japanese wooden plough is used, a rather clumsy and unhandy tool. A good picture of it will be found in Fesca's book. In my opinion our ameliorated iron ploughs might be introduced with advantage in Japanese agriculture. The common Japanese plough enters the soil about 15 cm. ; the soil is turned into beds 4-6 feet bread. This is done immediately after the harvesting of the barley. Soon afterwards the land is harrowed ; the harrow consists of a wooden bar with wooden teeth, directed backward, which is drawn over the field square to the direction of the beds, so that the ditches are filled at the same time with levelling the soil. The ploughing and harvesting are commenced early in the morning ; the implements are always drawn by one single animal. The ploughing is done the whole day through, it is only stopped during the resting hours for the people. The number of working hours per day averages 8 ; in this time one animal can plough $1\frac{1}{2}$ tan (0.15 H.A.).

The planting material is raised on seedling beds, like with us in Java. The seeds, however, are always sown as such and never laid out in the ear. Laying dry the seedling beds is never practised. The young seedlings are transplanted, when they are 35-45 days old and when there is sufficient irrigation water for fields. It seemed to me, that the plants at this age are somewhat shorter, plumper than with us. The tops are never cut off, as is often done with seedlings with us.

The usual planting distance is 0.85 feet, equal to 25 cm. As already stated, the plants are put out in perfectly straight lines. Generally 3 plants are put per hill.

The weeding is done by hand and often also with the aid of a tool, consisting in a wooden roll with wooden pens, stretching out from the cylindrical surface. This tool is moved up and down between the rows of plants ; the perfectly straight lines make this easy. It has been used also in the experiment fields in Buitenzorg with a certain amount of success. Other tools for weeding are not known in Japan.

The harvesting is done with a sickle. For the preparation of the grain a whole set of small implements are used, well fit for working on a

small scale. They can be actioned by hand or foot, or by electricity. A wooden cylinder, with rings of a heavy wire standing out of the surface beats the grain from the stalks. A mill with lists of hard wood embedded in clay or a recent improvement—with rubber between them is used for husking the grain. A sort of wooden mortar, wherein a small pillar is moved up and down by a crank, is used for removing the silver-skin and polishing the grain. This last tool may be seen often in rice stores in towns, moved by electricity.

The husked grain is packed in small bags, made out of rice straw. Burning the straw in the field is never practised ; the rice straw represents a certain value ; it is used for all kinds of purposes, for making the ropes used in transplanting the seedlings to the field, for making mats, such as are used in summer for shading houses, like an umbrella, or for baling rice ; also a sort of small baskets are made from these mats used for carrying sand for repairing roads. On a large scale rice straw is used for roofing material ; often house roofs are made out of a thick layer of straw ; and also for making the thick, elastic mats which are used on such a large scale for flooring the rooms of Japanese houses. In agriculture straw is used for protecting young plants by low hedges as a wind screen ; it is spread on the soil in growing water melons and it helps to close the barrels, in which night-soil is transported to the fields. Straw is used as a litter, in making stable manure, and is mixed into compost. The value depends largely on the place ; in the neighbourhood of large towns it has a far higher value than in more remote rural districts. The value will be often 1 sen per kwan (3.75 kg.) or even more ; per tan 100-150 kwan or still higher production are made, so that the profit on the straw may be per cho 10 yen and more.

Intensifying the Crop.

Repeatedly we have already explained, that the rapidly increasing population of Japan created a demand for rice growing so fast, that the extension of the paddy fields could not keep pace with it.

Since the equilibrium between local food consumption and local food production was broken, the solution of the problem of increasing the local food production has been sought in various directions. As we have seen before, since 1884 the rice fields were extended by 10.5 per cent, the dry fields by 32.4 per cent. Another measure, pointing into the same direction, was the fostering of the planting of second crops after the rice crop ; also by such a system, cropping the same field twice a year, some increase may be expected. In 1884 Fesca calculated that about 25 per cent of the rice fields were planted, after the rice, with a dry crop ;

for the years 1919 and 1920 the average figures were in thousand of cho (calculated from the statistics in the *Japan Year-book*, 1923) :—

Paddy fields with one crop .. 1850 cho, or 60.7%
„ „ with second crop .. 1196 „ or 39.3%

A third measure was the most successful. By ameliorating the system of farming, by the use of improved seed and a more liberal use of fertilizers,—what may be called by intensifying the rice growing—a material increase in the yield per acre was obtained. At present there is no country, where such high yields of rice are made, as in Japan.

In Fesca's time the average production per tan was estimated by him at 1.2 koku ; that was in 1885. The following list shows how the average yield per tan has increased gradually and regularly :—

1885	..	1.20 koku
1904—1908	..	1.57 „
1909—1913	..	1.63 „
1914—1918	..	1.81 „
1919—1921	..	2.01 „

These figures (from the *Japan Year-book*, 1923) are according to the experts rather somewhat too low. The averages include also the figures for the rice in Northern Japan, where conditions for the production are less favourable, so that they lower the average. The figures are interesting, as well in comparison with those of other countries, as with figures for earlier years in Japan. No other country in the world shows such high yields per acre. In America we find average figures for the last five years largely varying, from 2.42 bushels per acre (Florida) to 57.9 bushels (California) ; in clean rice this means 755 kg., and 1,824 kg. per H.A. In tropical countries like Java, Indo-China, the Philippines, an average production of 1,000—1,200 kg. per hectare may be considered a fair figure. In Japan it is about 3,000 kg., or practically three times this figure. It shows at once, what a high level rice growing in Japan has reached.

It appears from the figures, that this increase in production has been reached gradually. The constant upward march of the figure shows, how the improvement of the rice growing has worked further and further through. Two causes are especially responsible for this increase : the applying of larger quantities of manure and a better application of different artificial fertilizers ; and, on the other hand, the improvement of the planting material.

As we will see further on, both ameliorations worked together to increase the production. On one side, the improvement of the planting material made it possible to apply large quantities of manure. In Java

we find that on places, where the rice plants have soil of extreme fertility to their disposition, like at the entrance of the fresh irrigation water in the paddy field, they grow too heavy and have a tendency to layer. In Japan all varieties I saw used have short stiff stems, so that they will not layer so easily, even under heavy manuring. On the other side it seems probable, that only by using very productive varieties the heavy manuring gives its full effect, while less productive varieties would not react so strongly on this method.

We will consider both factors in detail in a following paragraph; before doing so it may be stated, that a very material rise in the market price of rice certainly has had a stimulating effect on improving the crop. We have already cited figures; for forty years rice was 6 yen per koku, now it is 33 yen, or more than five times as high. On the other hand, wages have increased considerably too; they are far higher than in countries where rice is cheaper, like Java or Indo-China. The daily wages of labourers in the experiment fields I visited, were practically three times as high as the ones we pay in our experiment fields in Java, amounting to 1.10—1.20 yen per day: the working day is, however, somewhat longer than in Java (8 hours in summer). Fesca mentions in his calculations on the cost price for his time, daily salaries of 10-15 sen, for other regions 20-30 sen. It is difficult to estimate what in those days average daily wages would have amounted to; but the striking fact remains that in these days rice cultivation was often not profitable, while it may be considered now to be generally given a good return.

The Use of Manures.

The use of farmyard manure and other natural manures dates already from old times in Japan. Originally, especially refuse was used as such, and also green manures. Fesca described in 1885 a whole list of fertilizers, which were used in those days by the Japanese farmer. It is remarkable what energy they showed in their struggle to obtain them. On page 61 (Vol. II) of Fesca's book it is mentioned, amidst a list of analyses of fertilizers, that Japanese junks went regularly to Wladiwostock to fetch refuse from there, which was used on the paddy fields of the home country for increasing the productive power. It is not astonishing, that the artificial fertilizers, when their use was developed in Europe, became rapidly popular among the Japanese farmers; they are used there now on a scale, which sometimes comes near to or even suprasses the use of them in European and American agriculture. Besides artificial fertilizers ("cash manure" as they are called in Japan) always still a large use is made of refuse materials for manuring the fields, in the first place of human

excrements. Early in the morning, one can see the transport of these in small barrels, on the typical low four-wheeled carts, from the town to the fields ; even what can be collected in public closets is carefully kept and used. On the farms the night soil and stable manure are kept for the use in the fields and also the ashes of wood and charcoal ; all sorts of refuse are turned into a compost. Green manures are applied in different ways ; sometimes it is done as with us in Java ; a leguminous plant is grown in rotation with other crops and ploughed under, before the rice is put out. Another way of supplying green manure is more characteristical for Japan ; on the land not fit for cultivation, grasses, shrubs and leaves are cut and collected, and this mass is spread out on the soil as a kind of mulch. In the tea plantations near Kyoto for instance, I saw early in July, the land covered everywhere with what seemed at first sight straw, but what was here and there still green ; apparently it was wild grass cut on the slopes of the neighbouring hills, used for mulching the fields. From a set of data on special crops and individual farms it may be deduced, that the use of natural manures to that of artificial fertilizers shows a proportion of $\frac{1}{2}$ to $\frac{1}{2}$ or $\frac{1}{3}$ to $\frac{2}{3}$. Artificial fertilizers were used in Japan in 1919 to a total value of 315 millions of yen. Prof. Kato gave, as a rough estimate for the total use of manure in 1923, 600 millions of yen, which seems to correspond well with the first figure. This total quantity is used on an area of roughly 5.5 million cho, so that per H.A. as an average more than 100 yen per year are spent on manure. Out of the calculations for the cost of production of rice and tea it appears again elsewhere, how large sums of money are spent on this item : of the cost of production of green tea leaves 40.5 per cent of the expenses are for manures ; for rice this percentage is 29.1 per cent. We have cited already that for rice 137.69 yen per cho were spent on manuring out of which figure 88.46 yen were for artificial fertilizers, 49.23 yen for natural manure. How rapidly the amount of manure applied has increased may be shown by the estimate, that 15 years ago the quantities of artificial fertilizers used were only 2/5 of what is applied now.

According to information obtained from Dr. Yonemura, who in the Central Experiment Station heads the division for manuring, in the rice growing especially nitrogen-manures are needed. A common practice is to give 50 kg., of N. per cho or 250 kg. of sulphate of ammonia. Uptil now as a nitrogen containing manure mainly soy bean cake was used imported from oil mills in Manchuria ; Japan proper covers only 10 per cent of the demand for this commodity. This press cake contains 6-7 per cent N. Formerly the proportion of prices was, that the N. in bean cake cost 3 yen per kwan, in sulphate of ammonia 3.5 yen ; now

the proportion is 5 yen in bean cake against 3 yen in sulphate of ammonia. So at present, the use of soy bean cake comes out to be more expensive than sulphate of ammonia. The representatives of the German works making nitrogen compounds from the nitrogen in the air had recently visited the experiment station and seemed to have the intention to throw out the bean cake by furnishing sulphate of ammonia at a low price. Even now it is already cheaper but the farmer is still better accustomed to bean cake.

Phosphates are considered less needed. The barley crop gets a good manuring of phosphates (35-40 kg.) $P_2 0_5$ which will be still beneficial to the rice afterwards. The phosphate fertilizer is generally given in the form of superphosphate. There are several works in Japan (Tokyo, Osaka, Shimonoseki and Kobe) where this fertilizer is manufactured from raw phosphates, imported from Angauer, Ocean Island or sometimes even from Egypt.

The potash manure was given formerly only in the form of wood ashes ; now the yields are higher, it is also put into the soil in artificial fertilizers. As often used quantity is 40 kg. of $K_2 0$ per hectare.

Lime is only used in exceptional cases, in some parts of Western Japan and in the regions along the Inland Sea. The rice fields are not acid ; the dry fields on the slopes of the mountains and at their base are often acid. As already stated above, often leguminous plants are used as green manures and interposed in the rotation of crops. They are usually manured with farmyard manure and wood ashes ; if artificial fertilizers are applied generally phosphates are given. Nitrogen fertilizers like sulphate of ammonia are never applied on leguminous crops.

Serious efforts are made to make the use of "cash manures" easier for the small farmers by establishing co-operative buying associations. In 1919, out of a total amount spent on artificial fertilizers of 315 millions of yen, a quantity of a value of 47,370,000 yen or 15 per cent were handled by co-operative societies.

The Use of Improved Planting Material.

The improvement of the planting material has been taken in hand on a large scale and with considerable energy and financial sacrifice. Since 8 years an amount of 120,000 yen is annually destined to this purpose by the Central Government ; the prefectural (local) agricultural experiment stations collaborate energetically for the same purpose. The work is distributed over the different bodies in the following way :—The central organization is run by the Government. It consists in a division of the Central Experiment Station in Tokyo with several branch stations in

various regions of Japan ; I visited the station at Kashiwara near Osaka. In these central stations the work comprises the selection and further breeding of pure lines out of well-known varieties ; crossing and further breeding of hybrids ; the attention is especially concentrated upon the making of new types and the first testing of them from a practical point of view. Before a new race is sent out, it is tested by this central organization during 3 years, to determine its value for practical agriculture. Formerly it used to be even 5 years, but it has been found not necessary to carry on the testing for such a long period. After this preliminary testing, the seeds are handed over to the prefectural stations ; I visited one near Fukuoka. In the last mentioned stations, the staff not only tests out the forms received from the central organization, but also it isolates, crosses, and purifies its own forms. The prefectural stations send out the rice seeds to the multiplication fields in the country and of the townships, where the forms are further tested and from where they pass over into the hands of the common farmer. Till this last distribution, all the seeds are distributed free of charge. It is estimated, that at present 70 per cent of the seeds used reach the farmer by the way sketched above.

The Government has considered some years ago to use its control of the channels, by which the seeds reach the farmers, for obtaining a certain standardization of the rice types, limiting the number of varieties and imposing the most desirable ones upon the commercial producers, in the same way as this has been done for the silk production. Professor Kato, whose advice was asked in this matter, had strongly recommended not to introduce such a measure, as he did not think it would bring advantages and as, on the other hand, he feared that too rigid a control in the matter of seed distribution might counteract the rise and the spread of new valuable varieties or hybrids. The measure has not been introduced.

Without such a rigid control the system of distribution sketched above has had for effect a limitation of the number of varieties with the farmers ; they are always grown in pure, unmixed fields ; if the work is carried out as it should be done, even the plantings of the farmer should represent pure lines. The varieties, planted on a large scale, are the following (figures for 1919) :—

Okute Shinriki	500,000
Nakate Shinriki	34,000
Wase Shinriki	29,000
Aikoku	163,000
Kamenoo	159,000

Omachi	100,000
Oba	50,000
Bozu	40,000
Sekitori	38,000
Hohoku	31,000
Ishijiro	34,000
Kokuryo Miyako	32,000
Miyako	22,000
Kameji	21,000
Takenari	20,000
Shiratama	19,000
Waseono	16,000
Muboaikoku	12,000

These varieties occupy in total 1,420,000 cho, or almost half the total annual area under rice. A few details about the principal ones may be added. The first point is, that the Shinriki rice occupies such a prominent place in Japanese rice culture. The three varieties mentioned are the late (Okute) Shinriki, the medium variety (Nakate) and the early Shinriki (Wase Shinriki); out of these, the first is by far the most important. This variety alone occupies 500,000 cho, equivalent with 16 per cent of the total area under rice. Under the early varieties Aikoku occupies a prominent place with 163,000 cho. When the very varying conditions of soil and climate in Japan are taken into account, not only caused by difference in altitude above sea level, but also in latitude, average summer temperature and the date of first frosts, the local differences are certainly not less varied than in tropical regions like Java, the Philippines and Indo-China, the limitation of the varieties grown means under these circumstances a high level of the agricultural technique. At present efforts are made to introduce and spread the Japanese varieties in the Japanese colonies, Formosa and Korea; the fact that it has already been possible to adapt a variety like the Shinriki to the climate of these other areas certainly shows, that it is possible, if one has once an excellent variety in hand, to provide a very large area, with far distant boundaries, with seed paddy of improved quality.

Prof. Kato was kind enough to give some details about the origin of some of the varieties. The variety Shinriki was discovered in 1877 by a farmer in Nakajimamura (Hyogo prefecture), by name Maruo Jujiro. In a field of bearded variety Teikichi he found a few ears without beards, he took three of them and sowed the seeds the following year. At once he understood to have found a valuable kind, by the shortness of the stem and the colour of the produce (in the husk). With another farmer,

Imawura Zenroku, he started the multiplication on his new variety. In 1883 the Shinriki was brought over to other localities, in the first years still within the same province ; since 1887 it was transported also to other provinces. Since 1897 the variety was planted on a large scale and became more and more popular. Afterwards a medium and an early form have been isolated from it. It is not known with certainty, if the three original ears come from one single plant and so may be considered as the starting point of a pure line.

Of the early varieties the Aikoku is the most popular one. It was discovered in 1894 by Libuchi Sanshichiro, a member of the Senate. It is often planted as the pure variety ; often also it is used as a parent in crossings. Prof. Kato made a hybrid of Aikoku with Shinriki in the experiment station at Kashiwara (1910) ; his object was especially to find a form, which would stand the leaf disease much spread in those regions (shiro hagare). Out of the F_2 generation a farmer in Mii, where the experiments on resistance against this disease were carried out, by the name of Tanaka Shingo, obtained a good line, which proved itself by further multiplication practically constant and which is now much grown in Fukuoka and Oita under the name Mii.

Kamenoo is an early variety, also found by a farmer in 1893 ; it is planted especially in Northern Japan, Northern Korea and Southern Manchuria. The Omachi, a variety with a medium date of ripening, was discovered in 1868 by a farmer ; it is especially popular in Central Japan. Omachi is an early variety ; it was discovered already 64 years ago in North-Western Japan. The late ripening Kameji bears the name of the discoverer ; it shows a very great resistance against a disease (Dactylaria); it is considered to be a spontaneous hybrid.

At present a few new varieties are promising ; their popularity is rapidly increasing. One of the best known is the Kokko, an artificial hybrid, obtained in Kashiwara, between Shinriki and Sekitori ; the last one was discovered 77 years ago by a farmer in the variety Sembonshu and is one of the rather popular medium varieties.

During the time of my visit to Southern Japan (end of June) the rice was just being planted out, so that not much could be seen of the distinctive characters. However, I have seen some herbarium material ; what was striking at once was the reduced length of the stems ; the tallest varieties were 3 feet ; most were shorter. The straw is strong and stiff ; the number of stems (with a planting distance of 25 cm.) averaged 18, for Shinriki 25.

On the method of carrying out the selection work Prof. Kato gave me the following information :—If the improvement of a certain variety

is planned, then the seed is collected in different localities, where it is grown; these seeds are sown out and two series of plantings are made with it: a first one of separate plants (one plant per hill) at the usual distance; a second series is planted in the usual Japanese way. The plants of the first series are only used for further multiplication. A certain number of these are selected, taking account of characters like number of grains per ear, number of ears, size of the grain, length of the culm, earliness (of the breaking of the inflorescence), strength and stiffness of the straw. From all these selected plants individual sowings are made, comprising 100 plants. The uniformity is studied, especially of the "breaking"; it may not differ among the plants more than one day; only for Northern Japan a somewhat longer period is used. If, in case of failure of the main stem, one of the side stems takes its place, the difference is less than a day. Besides the date of the breaking other characters are noted, like the number of culms and their height; for the first mentioned character the co-efficient of variation will be 21-25 per cent, for the second one 5 per cent. If the time allows it, also other characters are studied; otherwise the study is limited to these; further always the individual production is measured. The selected, uniform lines are multiplied and compared with the population; the better ones are chosen and multiplied on a large scale; as already stated, the preliminary testing is carried out during 3 years.—*The Tropical Agriculturist*, Vol. LXVII, No. 3.

IV

Agriculture and Science.

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The application of science to agriculture is a comparatively modern development. Since 1834, when Boussingault laid the foundations of agricultural chemistry, an increased and increasing amount of attention has been devoted to agriculture by men of science. I propose briefly to recapitulate some of the more important advances which have resulted from this impact of organized knowledge on the most ancient of the arts, and then to deal in greater detail with some of the agricultural problems of to-day in the solution of which science is certain to play an important part. In reviewing the development of agricultural science, two things must be kept in view—the influence of science on practice and, what is perhaps more interesting, the lessons which agriculture has taught and is still teaching the scientific investigator. I hope to show that the great

benefits that have flowed from the application of science to practice are not always on the side of agriculture, but that scientific method itself has sometimes profited from the association. Further, the man of science has had to realize that progress is possible without the aid of sicence, and that some of the greatest developments in agriculture, even at the present day, have been brought about by empirical means.

Examples of notable advances in agriculture which have taken place without the aid of science are to be found all over the world. In the Orient, perhaps the most remarkable is the cultivation of rice which has been developed by the people in the deltas of the great rivers to a high degree of perfection and carried up the slopes of valleys by means of a system of irrigated terraces. The care and skill which have enabled the cultivator to grow a semi-aquatic crop like rice on the steep hill sides of India and Ceylon cannot fail to command our attention and respect. In this development, science has played no part and even now has not completed the preliminary analysis of the factors involved in the growth of the chief cereal of the tropics. We can only guess at the sources of the nitrogen made use of by the rice plant. Again in Gujarat in the Bombay Presidency, an indigenous system of agriculture has been evolved to overcome a most difficult set of soil and moisture conditions. In order that the tilth may be maintained and the moisture conserved speed is essential in managing these soils. To get over the fields quickly, the crops are grown in straight lines ; simple but effective implements have been designed for sowing and interculture and a fast and powerful breed of oxen has been developed. The adaptation of means to end is remarkable and great natural obstacles have been overcome by the peasantry unaided. In the Occident, equally striking advances have been made by empirical means. Sub-soil drainage, the modern systems of tillage, the great progress which has been made in the breeding of live stock, the Norfolk four-course system of rotation—which followed the introduction of the turnip crop into Great Britain in 1730—are all improvements which owe nothing to the scientific investigator.

The early pioneers of agricultural science were chemists. A French chemist laid the foundation stone in 1834. Liebig's classical monograph on agricultural chemistry appeared in 1840 which instantly attracted the attention of agriculturists who, for the first time, were made acquainted with the help they were likely to obtain from the application of chemistry to the tillage of the soil. Three years later—in 1843—the Rothamsted Experiment Station was founded by Lawes, and the great era of agricultural chemistry began which continued till the end of the last century.

During this period agricultural science was a branch of chemistry. As long as the Liebig tradition endured, the analyses of soils and manures were regarded almost with veneration by the practical man, and great hopes were entertained that something approaching a royal road in the development of agriculture had been discovered. This phase lasted nearly fifty years, during which the use of artificial manures became firmly welded into the agricultural practice of the West. Experience of the new science, however, gradually showed that improvements in crop production could not always be achieved by appyling the principles laid down by Liebig. The deficiencies in the soil suggested by chemical analysis, were not always made up by the addition of the appropriate artificial manure. The feeling slowly developed that the problems of crop-production could not be dealt with adequately by chemistry alone. The physical texture of the soil was found to be as important as its chemical composition. The pioneering work of Hilgard and King in America led to the development of a new branch of the subject—soil physics—the exploration of which is still in progress. Pasteur's work on fermentation and allied subjects discovered a new world and laid the foundation of the modern work on micro-organisms and disease. The soil was soon found to be inhabited by bacteria and other forms of life and a new branch of agricultural science—soil bacteriology—arose. The organisms concerned in the nitrification of organic matter in the soil were discovered by Winogradsky and the conditions necessary for their activity were determined. Hellriegel and Wilfarth worked out the role of the organisms which produce the nodules on the roots of leguminous plants and in 1888 furnished a scientific explanation of the value of these crops in enriching the soil. The Liebig conception of soil fertility was thus gradually enlarged, and it became clear that the problem of increasing the produce of the soil did not lie within the domain of any one science but embraced at least three—chemistry, physics and bacteriology. The great value of this broadening of the basis of agricultural science was to afford an explanation of practices which had been arrived at on the basis of experience and to add a number of important principles to the subject. It was not till the beginning of the present century that investigators began to pay attention to what is after all the chief agent in crop-production, namely, the plant itself. The re-discovery of Mendel's law by Correns, the conception of the unit species which followed the work of Johannsen and the recognition of its importance in improvement by selection have led directly to the modern botanical studies of cultivated crops. These investigations are constantly broadening and now embrace the root-system and its relation to the soil type as well as resistance to disease. It is an arresting

fact that the development of modern plant-breeding came about indirectly and did not arise in the most logical manner, namely, as an outgrowth of systematic botany and the intensive study of the Linnæan species. Had the principles of systematic botany been rigorously applied to the various units which make up the Linnæan species and had anybody collected the numerous forms of almost any wild plant and grown them side by side from single plants, the principles underlying improvement by selection would have been apparent and a sure foundation for modern plant-breeding would have been laid.

The practical results which have followed the application of botanical science to agriculture during the last quarter of a century are very considerable. In wheat, for example, the labours of Saunders in Canada culminated in the production of Marquis—a variety obtained by crossing Red Fife with an early Indian wheat (Hard Red Calcutta). Marquis closely resembles Red Fife in appearance in the field and in the high quality of its grain. It differs from the parent in earliness and in having a shorter straw. Marquis is the most successful hybrid yet produced. Over 20,000,000 acres of this variety are grown in Canada and the neighbouring States of the Union. In Australia, the new wheats raised by Farrer are widely cultivated. In England, Biffen's new hybrid Yeoman has definitely established itself in the wheat-growing areas of the country. In India, the types produced by the Pusa Research Institute already cover more than 2,000,000 acres. The total area of the new varieties of wheat produced during the present century must be little short of twenty-five million acres. At a moderate estimate, the increased wealth produced by the application of modern methods of plant-breeding to this crop must be at least 20,000,000 sterling a year. If this annual dividend is compared with the capital invested, the return is many times greater than that yielded by the most successful industrial enterprise. The methods which have proved successful in wheat are now being applied in India to crops like cotton, rice, jute and sugarcane, and important results have already been obtained. During the next generation, the replacement of inferior varieties by more efficient and higher yielding types is certain to make rapid progress, and in a few years the total annual addition to the wealth of the world will run into hundreds of millions sterling. Important as is the total annual increment which follows the general adoption of a successful variety, nevertheless the gain per acre is small. Even in the most favourable circumstances it is not likely to exceed twenty rupees an acre. As in the case of Marquis and the Pusa wheats, the advantage is partly due to earliness and partly to the improved quality of the grain. The new varieties are more efficient and make better use of the food

materials provided by the soil than the old. Their cultivation secures a more certain crop and also one of increased market value. It by no means follows that the new kinds require more from the soil and that their cultivation will be followed by a loss of permanent fertility. The improvement is closely similar to that obtained by replacing an inefficient machine by one which is better designed to do the same work.

Even when the cultivated area of the world has been provided with better varieties, only the first instalment of the practical results, which flow from the modern studies of crops, will have been secured. The great problem of the agriculture of the near future is the intensive cultivation of improved varieties by which the present production can be vastly increased in quantity as well as improved in quality.

A survey of the development of agricultural science during the last ninety years reveals the important fact that until quite recently the approach has almost always been by means of one science. The researches fall into classes, each class coinciding with the limits of some well-defined subject like chemistry, physics, bacteriology, entomology or botany. Not only can the researches be easily grouped but the organization of agricultural workers closely follows the artificial sub-division of science which has grown up in the colleges and universities as a result of the exigencies of teaching and examinations. Further, the history of the application of each science to agriculture follows much the same course. First of all, there is a period of optimism after the publication of the early results. This is slowly followed by a more chastened outlook as it becomes apparent that the new science is not quite adequate by itself to deal with the many-sided problems of practice. Finally, direction is gradually lost and the effort not infrequently loses itself in detail.

I propose at this stage to examine two of the chief problems which now confront the agricultural investigator in India, and I hope to show that these problems do not fall within the limits of any single branch of science. It naturally follows, therefore, that the conventional method of attack cannot hope to be completely successful.

Irrigation and Agriculture.

The discovery of the right use of irrigation water is one of the chief tasks now before the Agricultural Department in India. As everyone knows, everything goes well in this country if the rains are timely, well distributed and ample in volume. Trade flourishes, there is contentment in the villages and in due course the officials connected with finance have the pleasant duty of announcing either the remission of taxation or suggesting useful schemes on which the surplus revenue can be spent. All

this follows because water is one of the limiting factors in the growth of crops. Hence the development of canal irrigation from rivers to supplement the rainfall. At first sight, all that seems needed is that the engineers should dam a river and distribute the impounded water over the countryside according to a time-table. The factor—shortage of water—which limits production can in this way be removed. For the canal to pay its way and to bring in the greatest revenue, the water has to be distributed so that the most expensive crops like cotton and sugarcane can be grown. This involves fairly frequent waterings so that there is no cessation of growth between sowing and harvest. Hence the institution of perennial irrigation and the concentration of the cultivated area commanded so that the highest duty of the water and the maximum revenue can be obtained. When, however, we carefully compare the growth of the same crop under canal irrigation and under normal rainfall, interesting differences can at once be detected. The irrigated crop as a rule does not appear to be quite at home. Ripening is frequently delayed and the quality of the produce is apt to be irregular and inferior. Further, the standard of cultivation under a canal tends to deteriorate. After a few years, the producing power of the soil falls off: patches of alkali land often appear and grow in size and there is a tendency for the villages to become malarious. Compared with the best well-irrigated regions or with localities where the crops are grown on the natural rainfall, the well-being of both plants and animals on the perennial canal leaves a good deal to be desired. Canal irrigation in the hands of the cultivator seems to put a brake on the wheel of life. In some places, as for example on the Nira canal in Bombay, the wheel of life is brought to a standstill altogether by the land becoming a wilderness of alkali on which nothing can grow. Here the canal has produced dead soil. How is it that things have gone wrong and why is there this difference between experience and theory? The answer is to be found in the fact that rainfall and canal irrigation are different things from the point of view of the plant. It is true that rainfall and irrigation have one factor in common, namely, the provision of water. In almost every other respect, however, they are quite different. Rain is a saturated solution of oxygen in water, and usually reaches the soil so slowly and at such long intervals that it does not destroy texture to anything like the same extent as canal water does. Moreover, it supplies the soil with oxygen in a highly effective form. Canal water is much poorer in oxygen, it destroys the tilth and the total period of its application to any particular crop is only a matter of an hour or two. Further, when the surplus irrigation water cannot flow away underground there is a gradual rise of the sub-soil water-level which may

reach almost to the surface. Small as these differences at first sight appear, nevertheless they are sufficiently important in the course of a few years to bring about a marked fall in the fertility of the soil.

Why there should be such a tendency towards intense malaria when dry crops are grown under canal irrigation, is a matter which has not yet been satisfactorily explained. Is it merely due to the accumulation of surface water providing breeding grounds for mosquitoes or is a part of the answer to be found in the lowered resistance of the people ? Have the wheat and other food-grains, produced under canal irrigation, the same food-value as those grown under natural rainfall or with the help of wells ? Do the nutritive and vitamin values of food-grains vary with the conditions of their growth ? Science cannot at the moment answer these questions, but there are indications that the food-value of the same cereal depends on the conditions under which it is grown. This matter urgently calls for careful investigation. McCarrison, working in Madras, was on the eve of throwing light on these questions when his researches were brought to an end by retrenchment. During the course of an exhaustive enquiry into the food-value of the rices in common use in India, this investigator found the various kinds differed considerably in nutritive value. No reason for this could be detected in their chemical composition and it appeared that the differences might be due in part to their vitamin content. As rice was not available at the moment, the matter was put to the test of experiment using the same kind of millet from the permanent experimental plots at the Coimbatore Experiment Station. These plots have been in existence about fifteen years and have been manured in various ways. In the feeding experiments on animals the millet grown on soil manured with cattle manure was more nutritious and contained more vitamins than that grown on soil manured with artificial manure ; that grown on exhausted soil being the worst of all in these respects. McCarrison writes "I was in the middle of this work when my researches came to an untimely end owing to financial retrenchments in India, so I was not able to repeat the experiment nor to extend them to other grains." That there does exist a definite relationship between the incidence of malaria and the way crops are grown is suggested by the observations of Bentley in Bengal. In this province, the prevalence of malaria and the inundation of the rice areas are closely connected. In such tracts as Eastern Bengal, which are subject to annual inundation, the rice crops are excellent, there are practically no waste lands, the population is large and malaria exists to so slight an extent as to be almost negligible. In parts of Central and Western Bengal, however, quite a different state of things exists. The greater part of the Districts of Nadia,

Murshidabad, Hooghly and Burdwan have been deprived of the natural inundations to which they were once subject by the construction of river-embankments. In the old days, 60 or 70 years ago, these embankments were kept in such bad repair that they did not prevent flooding of the country and their harmful effect was not apparent. When they were made really efficient barriers to the inundation, the protected areas began to suffer in several ways. The fertility of the soil diminished, the area of waste land increased, population declined and with it malaria increased to an appalling extent. Where rice is grown to perfection there is little malaria; where the crop is cut off from the necessary inundation, malaria is rife. In all probability the same rule applies to dry crops like wheat. It may easily prove to be that the intense malaria which often follows in the wake of the canal in North-West India is not altogether due to the mosquito but is a consequence of the lowering of the quality of the food-grains grown under canal irrigation. The subject is one which calls for early investigation, and it is hoped that McCarrison's interesting work on the influence of soil conditions on the nutritive value of the chief food-grains of India will be continued, and that the investigation will be widened to embrace the effect of the quality of wheat on resistance to diseases like malaria.

Of equal importance to the increase in malaria is the deleterious effect of canal irrigation on the fertility of the soil. When the desert is conquered by the canal, all goes well at first and large crops are raised with a comparatively small volume of irrigation water. As time goes on, however, the soil particles fall into a condition of closer and closer packing and as the natural texture of the desert soil is lost, more and more water is needed by the cultivator to raise his crops. Defective soil-aeration soon becomes a limiting factor in growth. The yields begin to fall off with surprising rapidity as is shown by the results with wheat at Mirpurkhas in Sind. The next stage is the appearance of alkali patches which slowly increase in size till the land goes out of cultivation. The rate of transformation of potentially fertile desert soil into useless alkali land is, other things being equal, inversely proportional to the size of the soil particles. Open, porous soils are not affected to any great extent by perennial irrigation. Close, heavy soils, containing a high proportion of fine particles, are, however, particularly prone to develop the alkali condition.

Very little progress in the prevention and cure of alkali soils has been made up to the present in India. All attempts to reclaim these soils on the large scale have proved to be impossible on economic grounds. Further, almost nothing is known of the causes which produce the alkali

phase. The conventional view that alkali soils are the natural consequence of a light rainfall, insufficient to wash out of the land the salt which always form in it by the progressive weathering of the rock powder of which all soils largely consist, is persistently reiterated. Hence alkali lands are considered to be a natural feature of arid tracts like the Punjab and Sind where the rainfall is very small. These ideas on the origin and occurrence of alkali land, however, do not correspond with all the facts. Alkali soils are common in the submontane tracts of North Bihar where the rainfall is between 50 and 60 inches. Arid conditions, therefore, are not essential for the production of these salts ; heavy rainfall does not always remove them. What does appear to be a necessary condition is defective soil-aeration. Whenever the air supply is cut off by the constant surface irrigation of stiff soils or by other causes, alkali salts sooner or later appear. If these barren areas are examined, they are frequently found to contain the bluish-green markings which are associated with the activities of anærobic bacteria. These organisms appear to bring about a reductive phase in the soil which involves the formation of substances like suplhuretted hydrogen and the matallic sulphides. When circumstances alter and oxidation again takes place, the salts of alkali land—the sulphate chloride and carbonate of sodium—are produced. That the origin of alkali is due to defective soil-aeration which slowly establishes an anærobic soil flora is supported by a large number of facts and observations. In the alkali zone of North Bihar, wells have to be left open to the air. Otherwise the water is contaminated by sulphuretted hydrogen, thereby indicating a well-marked reductive phase in the deep soil layers. In a sub-soil drainage experiment in the Nira Valley, Mann and Tamhane found that the salt water which ran out of these drains soon smelt strongly of sulphuretted hydrogen and a white deposit of sulphur was found at the mouth of each drain, proving how strong was the reducing action in this soil. Here the reductive phase in alkali formation was actually demonstrated. After drainage and aeration were established, the conditions necessary for alkali production were removed and the original texture and fertility of the soil were restored. These and many other examples point to the supreme importance of further investigation of the origin of alkali lands in India and the discovery of the conditions which are necessary for their formation. Once this is known, it will be possible to shape our irrigation policy so that the water can be made use of without lowering the permanent fertility of the countryside. Such an investigation is particularly necessary in India at the present time in view of the pending development of canal irrigation

in Sind. A barrage is being thrown across the Indus below Sukkur, and a system of intensive perennial irrigation was at one time contemplated for the growth of crops like cotton and wheat. The soil, however, is much closer in texture than that of the Canal Colonies of the Punjab, there are no deep sand layers to assist percolation, and the level of the sub-soil water is comparatively near the surface. There is therefore every reason to fear that the soil conditions of the area commanded by the Sukkur barrage are such that intensive perennial irrigation will produce a vast expanse of dead alkali land. Such a disaster can probably be averted by altering the method of distribution so as to give the land as much rest as possible from irrigation. A new method of irrigation must be evolved (intermediate between the modern perennial system and the old basin method) by which irrigation and soil-aeration can be combined. This is one of the results which is expected from the new Irrigation Experiment Station in Sind which has just been sanctioned by the Government of Bombay.

The effective addition of water to make up for a deficient rainfall is therefore not a simple matter. It lies far outside the province of the engineer and embraces not only the health and well-being of the people but also the main facts of rural economy as well as the problem of the maintenance of the fertility of the soil. Such questions do not fall within the limits of any one science, and it is obvious that their solution can only be accomplished by investigators of great experience, capable of bringing several sciences simultaneously to bear on these problems.

Diseases of Plants.

When we turn to the biological aspects of agricultural work, the great complexity of the subject and the interaction of the fields covered by the separate sciences, become most apparent. In following the growth of a crop from the seed, many branches of natural science are involved. The food materials provided by the soil are prepared by bacteria ; drawn into the plant and transported by physical means ; elaborated into useful products by chemical processes while the resulting growth produces organs which are studied by the botanist. Biological questions are therefore a complex of all sciences. Many of the problems of agriculture, particularly in the tropics, centre round the growth of the plant. How closely this complexity influences the successful solution of agricultural problems is seen when we consider the diseases of plants.

In recent years perhaps more attention has been paid to the diseases of crops than to any other branch of agriculture. One reason for this would appear to be that the detailed examination of the insects and fungi

concerned in plant diseases can easily be carried out by specialists in an ordinary laboratory and do not involve much equipment. In spite of the vast literature on diseases which has accumulated as a result of the researches of the last thirty years, agricultural practice has been remarkably little influenced. This result at first sight appears surprising. It seems so obviously the right thing to ascertain the nature of the pest and to attack its weakest and most vulnerable phase. It is, however, now being recognized that direct attack by assault and battery is nearly always useless and economic entomology and mycology are becoming transformed into plant pathology, thus bringing these subjects into line with the new developments in medical thought.

The moment we begin to study the diseases of plants from a broad standpoint it becomes apparent that a great deal besides the life-history of the fungus or of the insect is involved. The variety of the particular crop is perhaps more important than the parasite and the effect of the environment in both is often very considerable. That the insect or the fungus is only one factor in the problem is seen when large numbers of unit species, belonging to several varieties of a crop like wheat, are grown side by side under similar conditions for a number of years. The resistance of the unit species to the various rust fungi differs widely. Some unit species are practically immune, the rest are attacked to varying degrees. Although there is always plenty of infecting material the immune types escape.

It has not yet been possible directly to discover on what the immunity of certain species, varieties and unit species depends, but some light is thrown on the subject by another set of observations. It has frequently been noticed that improper methods of agriculture are almost certain to be followed by attacks of disease even in cases when the variety possesses a fair degree of disease resistance. Moreover, it has been found possible to induce experimentally attacks of disease by altering the conditions of growth. Thus einkorn (*Triticum monococcum L.*) the most rust resistant species of wheat known, became covered with pustules of black rust (*Puccinia graminis* Pers.) when grown during the hot season at Pusa. By altering the time of irrigation at Quetta, peach trees could be covered with green-fly whilst neighbouring trees of the same variety watered normally, remained free from this pest. Researches in other parts of the world tend to show that this and allied results follow alterations in the chemical composition of the cell-sap brought about by changes in the general metabolism induced by the altered methods of cultivation. The pest will only become acute if certain substances are present in the cell

in quantity—a close parallel with the recent work on cancer in Great Britain.

Twenty-five years ago detailed studies of the insect and fungus diseases of the sugarcane were the chief feature of the work of the sugar experiment stations in Java. These are now no longer considered necessary, as experience has shown that the best method of dealing with sugarcane diseases is by the efficient cultivation of suitable varieties. To grow the right kind in the right way is found in practice to be the most important factor in the control and elimination of the pests of the sugarcane. This experience is most significant. The Java sugar industry is perhaps the high-water mark of tropical agriculture and owes its present position to various natural advantages which have been developed to the utmost by the efforts of a succession of highly qualified scientific investigators who have explored, in the greatest detail, the various directions in which the production of sugar can be increased. It is most significant that as the investigation of sugarcane diseases became broadened and included all the factors, direct methods were given up and attention was directed solely to the variety and to its proper cultivation. This is after all only common-sense. Disease follows the breakdown of the normal physiological processes in the plant when the protoplasm of the cells loses its power of resistance to the inroads of parasites. Healthy plants, on the other hand, possess a high degree of immunity to insects and fungi. It is obviously more practical to prevent disease altogether by growing the right kind in the right way than to step in at the last moment and attempt to save a moribund crop.

The problems which centre round irrigation and disease are typical of those which now await solution by the man of science. They are not simple questions and they do not lie within the limits of any one branch of science. Each involves a number of factors, and it is obvious that the method of approach by means of the single science cannot hope to do more than accumulate data which may or may not be useful to some master-builder of the future. The approach by way of the single science is really an inheritance of the Liebig phase when agricultural chemistry and agricultural science were synonymous. As the subject broadened and deepened, first one and then another science became involved with the consequence that workers in these various branches of knowledge became colleagues of the agricultural chemist. The literature dealing with investigation and the teaching in the colleges and universities naturally followed the separate sciences. When about thirty years ago Departments of Agriculture began to make their appearance in various parts of the Empire, the organization was modelled on the teachings of the

colleges and the staff usually included a chemist, a mycologist, an entomologist, a bacteriologist and a botanist. As research extended, progress has always been marked by the addition of specialists whose business it was to deal with the application of some particular science to agriculture. Meanwhile the real subjects of research have far out-grown the old tradition founded on Liebig's work and the attack by means of the single science is no longer adequate. Some new method must be devised by which science can be more fully utilized in the advancement of agriculture. If we continue as at present the organization itself will soon become a bar to progress. The immediate question is: Is there any method other than that of the single subject by which science can deal with the problems of the cultivator?

How is the difficulty to be solved and how can science be brought to bear in a more effective fashion? Several suggestions have been made of which it is proposed to discuss two, namely, team work and a widening of the training of the investigator accompanied by a gradual re-organization of existing agricultural departments. The idea of team work in the solution of agricultural problems is a comparatively recent one and is a recognition of the complexity of present-day problems. Team work is another name for co-operation by which workers in single sciences can join forces to attack a complex question. It is a useful method for research institutes at which a number of graduates are working as apprentices in methods of research. By this means the post-graduate student not only has the opportunity of using his knowledge but also comes in contact with the essential nature of large questions. In agricultural research it is an excellent method for centres at which experienced investigators can direct and co-ordinate the efforts of advanced students. At the most, however, team work can do little more than make the most of a bad job. It breaks down when the members of the team are isolated and are placed face to face with problems in the strange places of the earth, where the sheltered corners created by the universities and by the endowed experiment station do not exist and where the working conditions can be summed up briefly in the three words—*payment by results*. Further, team work does not help to make investigators who can stand on their own feet. It rather tends to provide a framework for accommodating the unit very much as a regiment does. Another disadvantage is that to be effective team work always requires somebody to lead the team and to maintain direction. It also needs suitable material to lead. Team work in other countries is no new thing. It has long been common in the universities of the Continent where recognized leaders are frequently surrounded by young graduates eager to learn how to make the best use

of their knowledge. At many of the Continental universities, team work was in operation long before the term began to appear in our own literature. It is, however, in the study of biological problems that team work is most likely to fail. As emphasized above, the growth of a living organism like a plant involves many of the natural sciences, and it is difficult to see how team work is to give that insight into vital processes without which all such research remains sterile. A successful biological investigator must be able to visualize the complicated processes taking place in a plant, and to realize that such processes do not take place independently but that each influences the other. That this is being recognized is shown by the modern development at the universities of border line subjects like bio-chemistry, but what is wanted is something more than this; it is an integration in the mind of the investigator of the main facts of the chief sciences which bear on agriculture.

An alternative to team work in agricultural investigation is to so widen and deepen the training and post-graduate experience that the individual can successfully attack problems now attempted by the team. At the first sight, such a suggestion is liable to be ridiculed and set aside as utterly impracticable. Nevertheless I am convinced that it is the direction in which progress is most likely to be made. In putting these ideas into practice, however, we are at the outset confronted with a great difficulty. On the one hand, we have to train our future agricultural investigators in several sciences so that they can bring knowledge to bear on the problem in hand from several points of view. On the other hand, as knowledge accumulates there is so much to learn that men have to specialize in one branch of science in order to avoid too long a period of training. There are thus two opposing tendencies to be reconciled. Men who can integrate and who can apply several sciences to an art like agriculture are constantly needed for all kinds of applied work. To advance pure science the specialist is also essential. How far can these two different classes be trained together and at what point must they begin to follow different roads? This is a matter of organization of teaching in the universities. It is one which needs the most careful thought and one which will have to be solved if we are to reap the full harvest from the application of science to industries. Up to the present, the application of science to agriculture, although successful in many instances, nevertheless has not always led to useful results. If only the training could be broadened and the right type of man with the ideal combination of knowledge and aptitude could be set to work on the problems of to-day, it ought to be possible to accomplish more in the next generation than has been achieved during the last hundred years. The problems have been

defined and are before us awaiting solution. The scientific knowledge and the ability exist in the great republics of learning. In many cases the means for doing the work have been provided. What is needed is the happy union of all these factors—the trained investigator, the problem and the means.—*The Agricultural Journal of India*, Vol. XXI, Part III.

Absorption of Ammonia by Soils.

When first applied to the land, sulphate of ammonia, being readily soluble in water, is dissolved by the water which the soil contains. When used as a top dressing, especially on grass land, so that it does not come in close contact with the soil, it may sometimes remain undissolved until rain falls and washes it in, but the soil, generally, contains enough water to dissolve sulphate, if it is in close contact with it.

In a state of solution, the sulphate of ammonia spreads all through the soil by the fact of the movement of the soil water in every direction. It is obvious that unless some change takes place in its condition, it may be carried away in the drainage. This change, however, soon takes place. Clay and humus have the power of fixing ammonia or absorbing it. No arable soil is without a certain proportion of one or both of these constituents. Hence ammonia supplied is seldom lost. In what way the ammonia is fixed is not clearly understood, but it is probable chiefly by chemical combination; though there is no doubt capillary action assists in retaining it.

The humus and clay of the soil, however, can only absorb ammonia when it is either in the free state, *i.e.*, not combined with other substances —or in the form of carbonate. The ammonia or sulphate of ammonia must therefore be converted into one of these forms before it can be fixed. This is brought about by chemical action in the soil between the sulphate of ammonia and carbonate of lime, a substance which most soils contain.

It will be remembered that sulphate of ammonia is a compound of ammonia and sulphuric acid, and that carbonate of lime (or chalk) consists of lime and carbonic acid, when the two substances come into contact in the soil an exchange takes place: the ammonia and carbonic acid combine to form sulphate of lime.

The carbonate of ammonia thus formed can be absorbed and "fixed" by the clay and humus, and it is then practically safe from loss by drainage, at least until nitrification takes place. It has been shown experimentally that without the presence of carbonate of lime absorption of ammonia does not take place when it is applied in the form of sulphate or any other compound of ammonia except the carbonate.

The requirements for the absorption of ammonia applied as sulphate may be summarized as follows:—

(1) The presence of enough carbonate of lime in the soil to convert the sulphate into the carbonate of ammonia.

(2) The presence of clay or humus to absorb the carbonate of ammonia thus formed.

It must not be understood that these actions are immediate or complete. It is a common mistake, and one which leads to a good deal of confusion, that chemical actions take place as readily and completely in the soil as in the beakers and test tubes of the laboratory. It is really quite otherwise. Some sulphate of ammonia may remain unchanged for a considerable time though the supply of lime is plentiful.

As the sulphate sinks lower and lower into the soil most of it is then fixed; but probably many other actions take place, though generally on a small scale and with quite unimportant results. The gradual change is very useful, for it is the means of keeping up a gradual supply of nitrogen to the growing plant. The subsequent process of nitrification, or change to the nitrate form, is also gradual, and the benefit of the application is spread out over the growing season. This gives sulphate of ammonia a decided superiority and preference as a source of nitrogen. It keeps the crop growing.—*The South African Sugar Journal*, Vol, IX. No. 9.

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